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SECONDARY REINFORCEMENT: STIMULI ASSOCIATED WITH THE OFFSET OF NOXIOUS STIMULATION

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a dissertation entitled "Secondary Reinforcement: Stimuli Associated with the Offset of Noxious Stimulation", submitted by Paul Franklin Zelhart, Jr. in partial fulfillment of the requirement for the degree of Doctor of Philosophy.

ABSTRACT

These studies have attempted to determine the reinforcing characteristics of stimuli associated with the offset of noxious stimulation. In Study I the dependent measure was bar pressing. In this study response contingent presentations of a stimulus previously associated with the end of noxious stimulation suppressed bar pressing. From this result it was concluded that stimuli associated with shock offset are conditioned aversive stimuli rather than conditioned reinforcers.

The second study employed restraint and produced gastric ulceration as the dependent measure. In this study the presentation of an aversive conditioned stimulus during restraint increased the incidence of gastric ulceration. When presented alone or in combination with the aversive stimulus the stimulus associated with shock offset neither increased nor decreased the incidence of gastric ulceration. A discussion of various restraint techniques with regard to immobilization and discomfort is presented. Sprague-Dawley albino rats were used as subjects for both studies.

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Initially these studies were designed as a test of Mowrer's learning theory (1958, 1960). However as experimentation progressed the direction of the research shifted to the topic of secondary reinforcement in a more general sense. That a degree of unidirectionality was maintained was due to the constant watchfulness of my supervisiors. I would like to therefore thank Dr. Runquist for his guidance and help over the past several years. I would like to thank Dr. Rozeboom for his help in the design of the studies and with the formulation of the various problems of theory. Finally, I would like to thank Dr. Stretch for his help in all of the above categories and most especially for the loan of a great deal of equipment and technical assistance.

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Chapter I

The phenomenon of secondary reinforcement has a prominent place in the variform learning theories that hold drive reduction as requisite for learning. In general the drive reduction hypothesis states that for learning to take place stimulus and response events must occur contiguously and this conjunction must be closely followed by reinforcement; reinforcement in this context is usually delineated as a rapid diminution in need produced or learned sources of drive stimuli (S_D). In such constructions, primary sources of motivation are usually conceived of as need states which eventuate in proprioceptive stimuli (S_D); primary reinforcement is constituted by the reduction of such stimuli usually through need reduction. Since physiological deprivation states are intuitively inadequate explanatory mechanism for most human behavior, learned sources of motivation and reinforcement are included in all major theoretical models of behavior. An over simplified account of the acquisition process would specify that neutral stimuli consistently paired with primary drive and reinforcing events gain drive and/or reinforcing properties (secondary drive and secondary reinforcement). The criteria for established secondary drives and reinforcers varies but for the present purpose acquired drive will be defined as "learned responses having many of the general properties of all responses, and, in addition, the capacity to affect other responses in the same ways in which they are affected by motivational variables" (Brown,

1961). Secondary reinforcers will be defined as stimuli which through pairings with primary reinforcement "acquire the capacity to function much as the primary reinforcer originally did...; it is capable of reinforcing new learning and retarding the extinction of previously learned habits" (Kimble, 1961). The advantages of such conceptions could be found in their capacity to account for a broad range of behaviors. Too often, however, wide-ranging constructs receive broad application by virtue of their imprecision. This has been the case with the constructs of secondary drive and secondary reinforcement. Specification of the necessary and sufficient conditions for the development of secondary drive and secondary reinforcement has been and remains a critical question.

The present research deals with the phenomena of secondary reinforcement as defined by holders of a drive reduction hypothesis. Investigated are the conditions that have been specified, from such a framework, as being necessary and sufficient for the conditioning of secondary reinforcement.

More specifically, the observation is generally made that if secondary reinforcers are established through drive reduction then such phenomena should be associated with both stimuli paired with food and water presentations and with stimuli associated with the offset of noxious stimulation. Failure in such a demonstration, says Beck (1961), "... may be presumptive evidence in favor of the

opposite view; namely, the argument that secondary reinforcement is a phenomenon involving motivational increments, particularly those related to stimulating properties of the anticipatory response." To date there has been no generally recognized or replicated demonstration that stimuli associated with the offset of noxious stimulation become conditioned reinforcers.

Beck (1961) has reviewed a large number of attempts which he has classified according to the experimental technique employed. In the present literature review a modified version of Beck's classification of studies by techniques will be adopted. The classification is as follows: (a) response acquisition, including bar pressing, T maze learning, head turning, pushing a nose-key and shuttle-box responses; (b) response extinction; (c) delay of reinforcement; (d) response facilitation; and (e) preference testing (other than T maze). In addition to this classification, studies will be criticized on the basis of general experimental procedure and with regard to three criteria that have been developed from specific problems exemplified in the literature.

The first criterion involves the selection of a dependent measure. A variety of dependent measures have been employed; most of these are well investigated, clearly delineated responses. Some studies, however, have employed dependent measures or used experimental procedures which made interpretation of the employed dependent measure unclear. The first criterion (Criterion 1) then requires

the use of unambiguous procedures and dependent measures.

The second criteria involves the drawing of an analogy between studies of secondary reinforcement which use reward as primary reinforcement and those using escape from noxious stimulation as primary reinforcement. Several authors (Estes, 1949; Schlosberg and Pratt, 1956; Miles, 1956) have shown that reinforcers which were conditioned through food or water presentations have little or no control over behavior when the need state under which they were conditioned is satiated. Extending this finding to studies which employ removal of shock as the drive reducing event, a satiated condition would involve, firstly, the absence of shock. However, Miller (1951) has shown that there is an additional motivating component to shock, namely fear; for the present purpose fear will be operationalized as the presence of conditioned aversive stimuli. Miller (1951) has shown that animals will learn additional responses with termination of fear as the reinforcement. From such demonstrations it might be concluded that fear may be a potent enough motivating state that even in the absence of shock secondary reinforcers may control behavior. However, reasoning from the studies which establish secondary reinforcers through association with thirst and hunger reduction, when both shock and fear are absent little secondary reinforcement should manifest itself. Complete satiation may also mean, then the absence of fear. Indeed, Mowrer (1960) indicates that secondary reinforcers established

through association with the termination of aversive stimulation should not be effective in the absence of the prior associated source of motivation, and, indeed, in the absence of such a source of motivation may be aversive. The second criteria (Criterion2) then involves the requirement that either the noxious UCS or conditioned aversive stimuli should be present when testing for the secondary reinforcing properties of stimuli previously associated with noxious stimulus offset. Studies which did not meet this requirement but produced positive results present a special problem. These studies seem to indicate that either the analogy between appetitive reinforcers and shock reduction should not be made or that these studies are not demonstrating the phenomena of secondary reinforcement. For the present purpose Criterion 2 will be adopted. However, studies with positive results obtained in the absence of shock and aversive stimuli may be important sources of information as to the mechanism of secondary reinforcement.

The third criterion attempts the separation of reinforcing properties of stimuli associated with shock offset from other functions which these stimuli may serve. The definition of secondary reinforcement noted previously described secondary reinforcers as capable of reinforcing new learning and maintaining previously learned responses. Many studies attempt to show the reinforcing effects of a stimulus by demonstrating its potency in maintaining a previously learned response. However, the repeated occur-

ence of a response could result from the elicitation of the response by a previously conditioned stimulus. In experimental situations which fail procedurally to insure that reinforcing and eliciting functions are distinguished reinforcement becomes a superfluous concept. Studies in which training and testing involve the same response to the same conditioned stimuli provide the most extreme example of this type of confounding. The best possible experimental control would insure that the reference response has never been performed in response to the reinforcing stimulus prior to testing. This control is possible in studies which involve increasing the rate of a previously learned response or the learning of new responses through secondary reinforcement. Thus, the third criterion (Criterion 3) demands that experimentally the eliciting and reinforcing functions of the stimulus associated with shock offset be separated.

Before initiating the literature review some conjectures as to the nature of secondary reinforcement will be reviewed. These hypotheses have generated much research and are presented here as background.

Keller and Schoenfeld (1950) have proposed an additional specification of the necessary and sufficient conditions for the establishment of secondary reinforcement. These authors claim that a stimulus must be an S^D (discriminative stimulus) for some response in order to act as a secondary reinforcer. This statement, termed the "discriminative-stimulus hypothesis", has stimulated much

research. Two reviews (Beck, 1961; Wike, 1966) of research findings dealing with this hypothesis are available. Both condlude in a similar vein: "... since it may be possible to obtain secondary reinforcement without prior discrimination training and an S^D does not seem to be guaranteed as a reinforcer we can not accept cue functions as a <u>prima facie</u> evidence for secondary reinforcement" (Beck, 1961). Beck goes on to say, however, that the operations that increase discrimination seem also to make secondary reinforcement stronger.

A second hypothesis has stimulated little research. Wyckoff's (1959) hypothesis states that the reinforcing value of a stimulus is a product of its "cue strength". He has, however, failed to specify sufficiently the meaning of "cue strength" (see Kelleher and Gollub, 1962).

Better specified is a hypothesis by Egger and Miller (1962). These authors state that for a stimulus to be a secondary reinforcer it must provide information about the occurence of primary reinforcement. Redundant predictors of primary reinforcement would, according to this model, fail to acquire secondary reinforcing properties. That is, if two or more stimuli provide information about primary reinforcement the most reliable stimulus would be the strongest secondary reinforcer. Egger and Miller have data supportive of the hypothesis.

None of the above hypotheses holds undisputed sway. They may point the way, however, to additional specification of the conditions necessary for the establishment of second-

ary reinforcement.

In the following literature review the three criteria previously developed will be extensively employed. Additional criticisms will be made of individual studies. A summary of the studies and the criticisms applied can be found in Table I (p. 32).

Response Acquisition

Under the response acquisition paradigm an attempt is made to condition a response by means of a secondary reinforcer previously associated with the offset of noxious stimulation.

Bar pressing

Barlow (1952) presented evidence which was interpreted as indicating that with a single conditioning trial a stimulus immediately following shock offset acquired reinforcing properties. In detail, the study employed five CS-UCS training procedures. For Group A a 5-sec. CS was immediately followed by a 10-sec. shock. For Group B the CS accompanied and terminated with the final 5-sec. of the 10-sec. shock. Group C received a 10-sec. shock immediately followed by the 5-sec. CS. For Group D no CS accompanied shock. Group E received neither shock nor CS training. For one half of the rats under each training procedure illumination of the conditioning chamber served as the CS. For the remaining Ss darkening the conditioning chamber served as the CS. Twenty hours after the single training trial Ss were tested by returning them to the conditioning chamber. For one half of the Ss tested the appropriate CS (illumination or darkness) was

produced when the Ss contacted, with any portion of their body, a rod inserted through the chamber above the grid floor. For the remaining Ss in each group the CS was present when the Ss entered the chamber and was terminated when ever the Ss contacted the bar. The results showed only one comparison termed significant by the author. Subjects in Group C that produced the CS by contacting the bar spent more time doing so when compared with Ss given the opportunity to terminate the CS. Thus for Ss in Group C the CS appeared to have acquired positive properties.

In a similar study, Barlow (1962) has investigated the effect of overlapping the CS and the end of shock as opposed to presenting the CS shortly (.6-sec.) after the shock terminates. In a 2 x 2 factorial design rats were trained with either light on or off as the CS for shock and with either a .9-sec. overlap of shock and CS or with a .6-sec. gap between shock termination and CS presentation. CS and shock durations were the same as those used in the previous study. Similarly, a single conditioning trial was employed and on test days the dependent measure was taken as time spent (17.6-min. test period) in contact with a bar inserted through the conditioning chamber above the grid floor. Contact with this rod turned off the chamber illumination which was on for all Ss on the test day. For animals trained under the overlapping procedure the Ss that received illumination as the CS spent more time in contact with the bar than did the Ss trained with darkness as the CS, although the difference was of marginal significance ($P < .07$). Thus,

for these Ss the CS appears to have aversive properties. For animals trained under the gap procedure the Ss that had been trained with light as the CS spent significantly less time contacting the bar when compared with Ss trained with darkness as the CS. For these Ss the CS appears to have positive properties.

Thus, Barlow appears to have established weak but positive evidence. However, Beck (1961) has noted an alternative interpretation of Barlow's earlier study. Beck contends that if the conditioned stimuli were aversive the data may well be the product of the Ss freezing upon CS presentation. With regard to Barlow's (1962) later study this interpretation may still be entertained. However, to do so one must assume that Ss trained under "gap" procedures freeze when the CS is presented; while Ss trained under the "overlapping" procedure learn to approach the bar thus turning off the CS. Such an explanation seems overdrawn. However, it does point out the multitude of alternative explanations possible when ambiguous dependent measures are employed. Consistent with the interpretation of the conditioned stimuli being aversive in both studies is Razran's (1956) observation that backward aversive conditioning (shock as the UCS) is only possible when the CS occurs after the UCS has ceased rather than overlapping the UCS. Indeed, Mowrer and Aiken (1954) employing such training procedures showed subsequent presentations of the conditioned stimulus suppressed food reinforced bar press-

ing. Beck also challenges the possibility of establishing secondary reinforcement with a single shock-CS pairing. Such an eventuality seem totally inconsistent when compared with data obtained from studies employing CS-food pairings (Bersh, 1951).

Littman and Wade (1955) conditioned rats in one situation with a light associated with the offset of tail shock. Testing in another apparatus, experimental Ss did not differ from control Ss in the number of bar presses made for light. Deutsch's (1956; see also Littman and Wade, 1956) most telling criticism of this study was that one would also predict transfer of conditioned reinforcement from one situation to another; but data in support of this notion were not presented. Additionally, this study fails to meet Criterion 2; the findings may be the result of an absence of motivation (fear and shock) at the time of testing.

Wahlsten, Cole and Fantino (1967) trained rats in an apparatus having distinctly different "shock, neutral and safe" chambers. Two levels of shock were used to evaluate the effect of different degrees of aversiveness during training upon subsequent secondary reinforcement. Rats in the high (H) shock level group were allowed to escape from the "shock" to the "safe" compartment after 5-sec. of 1-m.a. shock. The Ss in the low (L) shock level group were allowed to escape from the "shock" to the "safe" compartment after 2-sec. of .4-m.a. shock. The Ss in the H group were allowed 15-sec. in the "safe" compartment before returning

to the home cage. The Ss in the L group were allowed 30-sec. in the "safe" compartment. Additionally, the L group had ten 30-sec. adaptation trials interspersed with the ten daily shock trials. The H group had 25 daily trials and no adaptation trials. Testing took place after daily training trials and for three days following the four days of training. Testing consisted of placing Ss in either the "neutral" (not previously associated with shock or escape from shock) or "safe" compartments with a bar which when pressed allowed access to the remaining ("safe" or "neutral") compartment. If Ss did not press the bar in 60-sec. the door was manually opened and the Ss were given 60-sec. to enter the opposite compartment. The animals failed to learn the bar pressing task and showed significantly shorter latencies leaving the safe compartment than they did in entering the safe compartment. The authors concluded that if anything the safe compartment was aversive, with the effect being greater for the H group. This interpretation is further supported by the fact that preference testing, prior to training, showed that all Ss spent more time in the safe rather than the neutral compartment. Like the previous study by Littman and Wade, the present study failed to insure the appropriate drive state at the time of testing (Criterion 2). In addition, the Ss were presented with an anomolous stimulus complex. That is, a "safe" compartment is only safe when in the context of escape-from-the-shock-compartment. When in the context of

the "neutral" compartment the "safe" chamber may be a backwardly-conditioned aversive stimulus.

Beck (1958) has performed a study which met all of the developed criteria. Beck trained rats to escape shock in a T maze with a lighted door and buzzer serving as cues for a correct response. Upon completion of 180 training trials, _S_s were locked in the choice point. A bar was introduced and shock was continuously presented. The bar when pressed by the _S_s in the experimental group produced both tone and light for 2.5-sec. Two 10-min. test periods were employed. There was some initial indication that both tone and light reinforced bar pressing but the effect was not strong and did not appear in the second test period. Furthermore, control _S_s initially trained to escape shock without light and tone made many more responses during the test period than did the experimental _S_s. These results, or lack of results, are important data in the context of the otherwise adequate experimental procedures.

T maze learning

The following studies, disregarding results, share a common difficulty. In all of them reinforcing and cue functions are confounded.

Smith and Buchanan (1954) and Buchanan (1956) performed several studies with the same general procedure. Rats were trained in a straight runway to cross an active shock grid to receive food in one of two distinctly different goal boxes. In a subsequent T maze discrimination

task it was predicted that Ss would learn with fewer errors when the shock-food associated goal box was made positive. The results upheld the hypothesis. In three additional studies (Buchanan, 1958) it has been shown that (1) rats would "increase their tendency to approach cues contiguous with escape from a fear-producing situation, as well as those contiguous with escape from shock"; (2) "the approach tendencies, acquired by hungry rats during training to cues associated with shock reduction and hunger reduction, were not appreciably affected by changes in the drive conditions of hunger and fear between training and testing"; (3) "shock reduction and hunger reduction were approximately equal in their effects on the strength of acquired tendencies to approach associated cues, and that the drives of hunger and shock and/or their respective incentives combine in some fashion in the development of these approach tendencies" (p. 362).

These studies share a common experimental problem in that goal box stimuli may have evoked more vigorous approach tendiencies in the experimental groups by virtue of their prior conditioning history. Such procedural confounding reduces the evidential worth of the positive result.

Nefzger (1957) in a series of three studies, using a design similiar to that of Buchanan, found a much different result. All three studies involved escape from shock being associated with distinctive goal box cues. These stimuli were then used as reinforcement for the

learning of a T maze task. The author found no evidence that the stimuli either reinforced or elicited the appropriate responses in this situation.

Head turning.

Coppock (1950, 1951) attempted to establish secondary reinforcement by pairing a blinking light in varing temporal relationships with the offset of tail-shock. In the subsequent test periods a head turning of more than 22 degrees to the side of center was reinforced by the presentation of the prior conditioned stimulus. Only rats that had been reinforced for head turns to their "non-preferred" side showed significant learning. However, Ss that had been trained with a CS that began just as shock terminated made significantly more head turns to the reinforced side (during the second of two test periods only) than did Ss that had been trained with a CS that overlapped or followed shock termination. The author interprets these results as positive evidence for the reinforcing properties of stimuli associated with shock offset. However, as Beck (1961) has noted, the same criticism that was made with regard to Barlow's (1952, 1962) studies may be applicable to the present study. That is, the Ss may have been freezing when ever the CS was presented. This study fails to meet criterion 1; the interpretation of head turning is unclear.

Key nosing.

Crowder (1958), in the final study in a series of four, presented rats with 100 inescapable, variable duration

(8-120 seconds) shocks the termination of which was paired with auditory and visual signals. Using these stimuli as reinforcers for a key nosing task did not produce an increase in performance by the experimental Ss.

Shuttlebox.

Hunter (1961) attempted to determine whether a stimulus associated with shock termination must be an S^D in order for it to be a positive secondary reinforcer. His design involved three yoked groups of rats. Group III was trained to bar press to terminate shock only when a buzzer was sounding. Group II received both buzzer and shock but could make no effective response. Group I received only buzzer presentations. In the subsequent test all Ss were required to run from one side of a straight runway to the other in order to receive buzzer presentations. The Ss in Group III made significantly more crossings than did Ss in Groups I and II. Group II Ss made significantly more crossings than did those in Group I. The author concludes that these results demonstrate the reinforcing properties of shock-termination associated stimuli. The S^D hypothesis received only partial support since both Groups II and III showed significant improvement over Group I. Additionally, the dependent measure was ambiguous; increased crossings may have indicated an increase in the general activity level of Ss that had received CS shock pairings previously.

Response Extinction

Several studies have been attempted using the same general design. This procedure involved comparisons of rates of extinction with and without presentation of the secondary reinforcer.

In Crowder's (1958) second study rats were trained to nose a panel (pigeon key-like apparatus) to shut off shock. Each successful response was accompanied by visual and auditory stimuli (.5-sec. duration). Each of the 100 training trials involved a gradual shock onset and the Ss could not successfully respond until shock reached its maximum (25-sec. period). Experimental animals were presented with the conditioned stimuli during conditioning and extinction. One group (G-II) of control Ss were similarly conditioned but were not presented with the stimuli during extinction. A second control group (G-III) was presented with the conditioned stimuli only during extinction. During four 2-min. extinction periods response rate was significantly higher for Ss in the experimental group. The group designated G-II responded at a significantly higher rate when compared with the other two groups that no longer received presentations of the conditioned stimuli. A third study was done with only the variable of gradual shock onset altered. In this study shock was administered at the maximum level at onset. No differences between experimental and control animals were found in the subsequent extinction trials.

Crowder's studies are apparently positive findings. They however suffer from a lack of adequate reporting; these studies appear only in Beck's 1961 paper. Much of the detail necessary for a clear interpretation is lacking. The procedures employed during extinction are, for instance, not clear. If shock were not present during extinction criteria 2 would be applicable. Four extinction periods were reported to be 2-min. in duration. Since shock onset require 25 sec. it is doubtful that seven and 1/5 trials were run, with shock present, during a single extinction session. This would seem to indicate that shock was not present during extinction and that criteria 2 is applicable as a criticism. Crowder's work will be included in Fig. 1 as a weak positive finding.

Murphy, Miller and Brown (1958) conditioned rats to make a shuttle box avoidance response. During training light was presented after each barrier jump. Under extinction procedures, Ss receiving the light after each jump had significantly more trials to extinction than did control animals. While the authors interpreted these results to mean that the light had secondary reinforcing characteristics an alternative construction is that through backward conditioning the light was aversive. Thus, the light might have maintained fear at a higher level in the experimental Ss during extinction.

Beck (1961) also cites his own unpublished research in which Ss were trained to escape shock through

the lighted member of a pair of doors. The Ss were then placed in the situation with shock continuously on and no escape allowed. Pressing the other door was not reinforced with light. Under these conditions, Ss pressed the light producing door significantly more often. Eliciting and reinforcing functions are, as Beck notes, confounded in this study. That is the lighted door may have evoked additional door presses rather than reinforcing door presses.

Murray and Strandberg (1965) trained three groups of rats to terminate shock and a buzzer by pressing a bar. Group I received a 3-sec. light following immediately after the bar press and shock-buzzer offset. Groups II and III did not experience shock-termination-light pairings. During testing, Ss could escape the buzzer by running down a straight runway to a goal box. For Ss in Groups I and II escape into the goal box was reinforced by a 3-sec. light. Group III did not receive the light during extinction. The Ss in Group I required significantly more trials to extinction. The authors attributed this effect to the reinforcing properties of light for this group. But once again, the criticism made of Murphy's et al (1958) study is relevant. The light could have been a backwardly-conditioned aversive stimulus which maintained behavior in the experimental group at a higher level than in the control animals.

Reversing the usual procedure somewhat, Evans (1962) conditioned rats to press a bar for a sucrose reward. Each bar press was accompanied by a tone. The tone was later

paired in another situation with either the onset (avoidance group) or offset (approach group) of shock. A third group (neutral group) received shock only. Subsequently all Ss were returned to the bar pressing situation and extinguished (i.e. no sucrose reward) with only the tone as reinforcement. Post/pre-test ratios of bar pressing for each animal were computed. The rats in the approach group showed the highest ratio (least reduction in performance). The neutral group was intermediate and the avoidance group showed the greatest reduction (lowest ratio). Subsequently, the avoidance and approach ratios were divided by the average ratio of the neutral group. The mean ratio for the approach group was 1.37 with a range of 1.06-1.81. The mean ratio for the avoidance group was .53 with a range of from .20 to .80. A two tailed non-parametric comparison of these scores yielded a $p < .0005$. Such result appears to indicate that cues associated with the onset of shock hasten extinction while cues associated with the offset of shock retard extinction. The results of this study appear to be positive evidence for the reinforcing effects of stimuli associated with shock termination.

Two experimental criticisms seem appropriate with regard to Evans study. First, the control group and the experimental groups were not equally familiar with the tone at the time of testing. A better control group would have received the tone during the inter-trial interval

during the conditioning phase. Since the control group is taken as a base time for subsequent group comparisons this criticism may be important. Secondly, this study violates criteria 2. From at least Mowrer's (1956, 1959) position this study does not fulfill the requirements as a study of secondary reinforcement. If it is accepted as a study of secondary reinforcement criteria 2 should be rejected and this study would be strong evidence in opposition to Mowrer's approach. The resolution to this dilemma may well rest in theoretical formulations of secondary reinforcement other than those being investigated in this paper.

Delay of reinforcement.

Only one study of this type is offered and its results are not statistically significant. Crowder (1958) trained rats to press a panel with their noses to terminate tail shock. The period between the Ss response (2-sec.) and shock offset was "bridged" by white noise. Rats receiving this signal improved their performance of the task when compared with control animals that had the same delay of reinforcement by no "bridging" stimulus. The increase in performance, however, was not significant (at the .069 level).

Response Facilitation

Under the response facilitation paradigm an attempt is made to manipulate the rate of a prior learned

response through the presentation of secondary reinforcing stimuli. Using such procedures Lee (1951) trained three groups of rats to bar press for food. Subsequently, classically conditioned tail-shock and tone pairings were given to each group. For a separate groups tone was associated with shock onset, offset or was not associated with shock. The Ss were then returned to the bar pressing situation and tested with the tone as reinforcement for bar pressing responses. Tone inhibited bar pressing equally in all groups that had previously had tone and shock associated in any temporal pattern.

Mowrer and Aiken (1954) found similiar results in a study which involved suppression of bar pressing for a food reward. Stimuli associated with the termination and immediately following shock offset were aversive. Mowrer and Aiken suggest the result may be due to an absence of the relevant drive state in the testing situation. This criticism can also be extended to Lee's (1951) study and was earlier applied to the study by Evans (1962).

Wagman and Allen (1964) used a design which evaluated varying numbers of shock and tone pairings. Tone was associated with shock offset 2, 4, 8, 12, 16, or 20 times for six experimental groups. Three control groups were used; one received 12 shocks the other 20 shocks, neither was presented with the tone; the third group received neither shock nor tone. All Ss had,

prior to shock-tone conditioning trials, learned to bar press for food on a CRF schedule. In the third phase of the study all Ss were returned to the bar pressing situation and the tone alone was made contingent upon bar pressing. Post/pre-trial ratios were computed for all Ss. The Ss in the group receiving 12 tone and shock pairings made significantly more responses than the other experimental groups and the two control groups that had received shock. The groups which received neither shock nor tone, however, had the highest ratio. The author claimed the results of the group receiving 12 shock-tone pairings as evidence for the positive reinforcing properties of shock-termination associated stimuli. However, Longstreth (1965; also see Wagman and Allen, 1965) has pointed out a number of problems in this study. Namely, the controls were inappropriate because the experimental and control animals were not equally familiar with the tone; the tone seemed to suppress bar pressing in all but one of the shocked groups; the statistical treatment of the data was inappropriate. Additionally, in the bar pressing situation the relevant drive (fear) was not experimentally assured.

Forrin (1966) used a factorial design which allowed him to evaluate several variables: "(1) temporal relation of cue to shock (onset or offset); (2) number of affect-conditioning trials; (3) strength of hunger drive during testing (3, 6, or 23-hr. of food deprivat-

ion); and (4) similarity of affect-conditioning and testing environments (identical or dissimilar)." All Ss (rats) were initially trained to press a food-trough for a food reward. Then affect-conditioning was given in the same or a different environment according to group assignment. In the third phase the Ss were returned to the operant situation; trough pressing produced food and tone. Tone suppressed trough pressing. The effect was greater for Ss that had tone associated with shock onset. Amount of suppression was an increasing function of the number of shock-tone pairings and a decreasing function of the length of food deprivation during testing. All the results were highly significant and no evidence for the positive reinforcing effects of stimuli associated with shock offset were found.

Dinsmoor and Clayton (1963 and 1966) have produced a series of studies which are as a unit methodologically complex and at times unclear; individually the studies are subject to a variety of criticisms. The overall findings, however, are positive.

The first study (Dinsmoor and Clayton, 1963) involved several stages. Rats were initially trained to nose a pigeon key to turn off shock. The second stage involved discrimination training in which the pigeon key presses were only effective in the presence of white noise. The final chain of behavior involved a bar press (VR3) for the production of white noise; 30-sec. after

the last bar press in the presence of white noise a response to the pigeon key became effective in terminating shock. Comparisons of the rate of bar pressing before and after noise onset led the authors to conclude that the noise itself was the immediate reinforcing agent for bar pressing. Additional evidence for this interpretation was obtained when the pigeon key nosing requirement was eliminated. Under this procedure shock terminated automatically 30 sec. after the last bar press in the presence of noise. Under these conditions key nosing extinguished while bar pressing continued virtually unchanged. However, elimination of the noise or elimination of the dependency of noise or bar pressing led to a gradual reduction in bar pressing rate.

Dinsmoor and Clayton (1966) have pursued this problem in two more recent studies. In the first of these, rats were trained on a VR schedule to escape shock by pressing a bar. Noise was then substituted as the immediate consequence of lever pressing. Shock offset was initially delayed until five seconds after the last response in the face of noise. Eventually, the delay of shock offset, and duration of noise, was increased to 30 seconds. In the next phase of the study presentation of white noise was not contingent upon bar pressing. Rather noise came on according to

a temporal criterion (the mean number of seconds each S had previously taken to produce noise on the four preceding training sessions). The criterion for terminating shock once noise had appeared remained the same. Under the non-contingent conditions response rate fell sharply. The authors take this drop in performance to indicate that the onset of noise was the reinforcing event under the contingent procedure. When the noise was again made response contingent, in the final phase of the study, the response rate returned to its former level.

The authors argue that the contingent procedure provided immediate reinforcement for bar pressing, while under the non-contingent procedure reinforcement was only fortuitously paired with bar pressing. The authors noted, but dicounted, the possibility that the differences in the obtained rates might have been due to differences in the criterion for the offset of shock. They claimed that the difference in delay of shock offset between the contingent and non-contingent conditions was small when compared with the dramatic changes in rates under the two conditions. Additionally, the authors noted that pressing rates were much lower in the presence of noise than just prior to the onset of noise. They reasoned that such an event might have been due to the white noise as a reinforcer or it could have been attributed to the additional delay of shock offset imposed whenever an animal bar pressed in the presence of white noise. In a second study, white noise

was terminated 30-sec. after onset regardless of the number of responses made in its presence. Once again, response rates prior to noise onset were higher than response rates in the presence of noise. The authors concluded: "the conclusion seems almost inescapable that pressing before onset of the noise is reinforced in a way that pressing after the onset is not, i.e., that the noise serves as a conditioned reinforcer."

Dinsmoor's studies present a new direction in the research devoted to the present topic. Indeed, operant methodology may afford more appropriate procedures for testing the secondary reinforcing properties of stimuli associated with shock offset. Of the three studies reviewed the 1963 study is least subject to criticism. In reviewing this study Logan and Wagner (1965) agree with the author that Dinsmoor has made a rather convincing case but goes on to say that since Dinsmoor and Clayton, "ultimately permitted escape from the shock, it is possible that the tendency to press the first bar increased because of some round about primary negative reward from the eventual shock termination." The 1966 studies are subject to a similar criticism in that in the final phase of the experiment both presentation of the CS and shock offset were made "non-contingent." That is, primary and secondary reinforcement were confounded. Further, all the studies involved complex shaping procedures. In the first study key nosing became

effective 30-sec. after the final bar press. In the later studies shock offset, after white noise appeared, was delayed up to 30-sec. in the final phase of training. Such procedures provide the opportunity for the Ss to adopt a chain of responses that, as Harker (1950) has shown, help maintain performance when reinforcement is delayed. If such were the case in Dinsmoor and Clayton's studies shock offset rather than noise onset would provide reinforcement for bar pressing. Dinsmoor and Clayton can muster some evidence against this argument from the 1963 study in that elimination of the key-nosing requirement should have disrupted such a mediating chain. In summary, these studies seem to suffer primarily from such complex procedures that clear interpretation of them is very difficult.

Preference Testing

Under this procedure shock offset is associated with a distinctive environment. Subsequently the Ss preference for the shock-offset situation and other control environments is assessed by presenting both alternatives to the subjects.

Beck (1961) reviewed three studies which dealt with Ss preference for environments which had previously been associated with shock termination. Goodson and Brownstein (1955) conditioned rats to escape from a shock chamber into a distinct escape chamber. The animals were then placed between an escape chamber and a neutral chamber and their preferences were established. The Ss spent more time

in the escape chambers. However, eliciting and reinforcing functions were confounded and no procedural assurance of the relevant drive state was provided.

Montgomery and Galton (1956) offered results in a similar study which managed to control the cue functions of the conditioned stimuli. That is, rats were placed in a trolley having a grid floor. As they were drawn from one compartment to the other shock was ceased. So, while one compartment was associated with shock and the other with removal from shock, the Ss had no opportunity to practice running escape responses. When given a choice between the escape and shock compartments, Ss spent more time in the escape compartment. This, however, can be interpreted as avoiding the shock compartment rather than demonstrating reinforcing effects of the escape chamber. A better study would combine Montgomery's et al training procedure and Goodson's testing procedure.

Gleitman (1955) has done the study proposed above. It was found that Ss preferred the escape chamber when given a choice between escape and shock chambers. However, no preference was demonstrated between neutral and escape chambers. Beck has criticized this study noting that the conditioning was done in an open room. Thus cues associated with onset and offset of shock may have been "ambiguous." In addition, the number of Ss was not large and the experiment was a teaching device employing eighteen "experimenters" simultaneously present in the experimental situation.

These criticisms not withstanding, the results of Gleitman's study remain as one of the few positive findings which seems not to be obviously confounded. Additionally, the preference for the escape chamber could be viewed as escape from the conditioned aversive stimuli associated with the shock chamber.

Finally, Lawler (1965) trained rats to escape shock, in a Grice type discrimination task, by running into one of a pair of distinctively different goal boxes. One group of Ss was then tested for several non-shocked trials to assess their preferences for the two goal boxes. Another experimental group was similarly tested after the apparatus had been altered to create a "neutral" condition. This was accomplished by altering the auditory cues, color and texture of the start box and connnecting alleyway. One control group was run under each of the two experimental procedures; however, shock was omitted during training and testing for these animals. The experimental Ss tested under the neutral condition demonstrated a significantly greater preference for the goal box which in training had been associated with shock reduction than did the Ss tested under the unaltered training conditions. Both of these groups showed significantly greater preference for the shock-termination associated goal box when compared with the non-shocked control groups. The authors noted that the surprising performance of the experimental group tested under the unaltered conditions may have been due in part to a breakdown of

discrimination due to an extremely high drive state. Such an interpretation gains force when the data are closely examined. While the experimental Ss tested under the neutral conditions chose the shock-termination associated goal box about 76% of the time on the average, the Ss tested under the unaltered conditions chose the appropriate goal box only about 59% of the time. If one noted that there were no "no choice" trials by these Ss, the result could be viewed as a nearly chance performance of the discrimination task by the latter group. In addition, the performance of the group tested in the neutral environment failed to conform to the procedural analogy previously developed from studies of secondary reinforcers conditioned to food and water presentations. That is, the procedure did not experimentally insure that the relevant drive state existed at the time of testing for the group run under neutral conditions.

Summary

A summary of the studies this far presented is shown in Table 1. The studies are classified as to their claimed positive or negative result and with regard to the criticism made of each study in the sight of the criteria that were developed.

Table 1

Summary of the reviewed studies and their results

CRITERIA APPLIED	Ambiguous Response	Eliciting & Reinforcing Functions Confounded	Presence of Relevant Drive at Testing	Met Criteria
POSITIVE FINDINGS	Barlow, 1952, 1962	Buchanan, 1954	Evans, 1962	Dinsmoor, 1966
	Coppock, 1950, 1951	Beck, 1961	Wagman, 1964	Crowder, 1958
	Gleitman, 1955	Goodson, 1955	Lawler, 1965	
	Hunter, 1961			
	Montgomery, 1956			
	Murphy, 1958			
	Murray, 1965			
NEGATIVE FINDINGS		Nefzger, 1957	Littman and Wade, 1955	Beck, 1958
		Crowder, 1958	Wahlsten, et al* 1967	Forrin, 1966*
			Lee, 1951	
			Mowrer,1954*	

* studies showing stimuli associated with shock offset to be conditioned aversive stimuli

From Table 1 it can be seen that there are nearly as many negative findings in the literature as there are positive results. The number of negative findings that do not appear in the literature are of course unknown. Only four studies

met all the criteria. These are equally divided in terms of result; and they share very little methodologically. Dinsmoor and Clayton's (1966 and 1963) studies are complex in terms of method but seem to be strong positive findings. Crowder's (1958) study may suffer defects but in terms of the criteria presented must be taken as positive evidence. Beck's (1958) study is ambiguous in result; while Forrin's (1966) study is strong evidence that stimuli associated with shock offset are aversive.

Of the positive finding studies which fail to meet one of the criteria, the studies which failed to insure the presence of shock or conditioned aversive stimuli at the time of testing are most interesting. If one is willing to accept the criteria applied to this category as valid, these studies were not studying secondary reinforcement as conceptualized by theorists that endorse a drive reduction hypothesis of learning. The positive results remain; needless to say, such findings require a re-evaluation of existing theory. The remaining positive studies are less interesting because their procedural deficiencies do not allow clear interpretation of results.

The studies showing negative results are impressive primarily by virtue of their number. In large measure their procedural deficiencies disallow their results as definitive.

The preceding literature review provides no definitive answer as to the necessary and sufficient conditions for the conditioning of secondary reinforcement to noxious stimulus offset. Studies have been reviewed that found stimuli associated with shock offset to be reinforcing, neutral or aversive. The aim of the present research was to devise an experimental procedure whereby the rate of occurrence of a response might reflect the reinforcing, neutral or aversive properties of stimuli made contingent upon that response. The design developed also met the three criteria noted earlier.

Chapter II

Method

Study I

General Design

The present study was designed with regard to the considerations noted in the preceding literature review. An attempt was made to design a study that would meet all of the criteria previously developed. The study could be described as a response facilitation study; the dependent measure was bar pressing. The following is an overview of the procedures and hypotheses: Three groups of rats were trained to bar press for a water reinforcement on a CRF schedule. After the bar pressing behavior had stabilized, the bar pressing situation was slightly modified and all _S_s were given a number of conditioning trials.

For all groups one stimulus signalled shock onset and was expected to have become aversive. The two experimental groups were also trained with an additional CS that signalled the end of shock and the aversive CS. That is, for the two experimental groups a distinctive stimulus _signalled_ the _offset_ of the conditioned aversive stimulus and shock and should have gained secondary reinforcing characteristics. For the control group this stimulus appeared during the intertrial interval and was not associated with shock. During the testing phase the experimental _S_s were returned to the bar pressing situation; for a

specified period of time the conditioned aversive stimulus was presented which suppressed bar pressing. During this period, for one experimental group (Group I) the secondary reinforcing CS was made contingent upon bar pressing. The second experimental group (Group II) was not presented with the secondary reinforcing stimulus during testing. For the control group (Group III) the secondary reinforcing CS, as with the Group I, CS was contingent upon bar pressing during testing.

The predictions that follow from this design were: (1) That if stimuli associated with the offset of shock become secondary reinforcers, then the experimental Ss (Group I) given response contingent presentations of the reinforcing CS during testing should have a higher bar pressing rate in the presence of the aversive CS when compared with the experimental Ss not so treated (Group II). (2) Conversely, if stimuli associated with shock offset are aversive, experimental Ss (Group I) for whom these stimuli were response contingent during testing should show a reduced bar pressing rate (i.e. increased suppression of bar pressing) when compared with experimental Ss (Group II) not presented with such stimuli. (3) If the stimulus employed in the experimental groups as the signal for shock offset has no intrinsically reinforcing properties the control group (Group III) should not differ significantly in bar pressing rate from the experimental group (Group II) which was not presented with the secondary reinforcing

stimulus during testing.

This design experimentally insures the presence of the appropriate drive state during the test period by means of the aversive CS. Eliciting functions of the secondary reinforcing stimulus are controlled in that the Ss had no experience with bar pressing for a secondary reinforcer. Finally, the reference response was unambiguous. Unlike many of the dependent measures reviewed earlier, rate of bar pressing could not be easily confounded with other prepotent responses to aversive stimuli.

Subjects

Twenty-four male, Sprague-Dawley albino rats were obtained from the Dan Rolfsmeyer Laboratories of Madison, Wisconsin. All animals were 90 days of age on arrival.

Apparatus

The apparatus consisted of a sound resistent test chamber (Lehigh Valley Electronics type) equipped with a single lever and water dipper. Relay equipment and electronic timers, located in an adjacant room, controlled the experimental contingencies automatically.

During conditioning the sound resistent chamber was modified by the insertion of a partion which divided it into two chambers of equal size. Additional partitions prevented the animal contacting the bar (withdrawn during conditioning) and the water cup. This allowed two animals

to be conditioned at a time. The partition prevented the Ss seeing each other or coming in contact. Shock was provided by means of a Lehigh Valley Electronics shock generator; shock was mechanically "scrambled" and delivered through a grid floor in the sound resistent chamber. All shocks were .5-sec. in duration; the shock intensity was 3-m.a. for the first conditioning series and 5-m.a. for the second conditioning series. The aversive conditioned stimulus was an 82-db. white noise which always preceded shock by three minutes. The stimulus associated with shcok offset was a 92-db., 4,000 cycle per second pure tone of approximately 1-sec. duration. Sound level calibration was determined prior to each conditioning and testing session by means of a Dawe 1400E sound level meter. A commercially manufactured white noise generator with appropriate amplifiers and speakers were used to produce the conditioned stimuli. Two different size water cups were used to control water reinforcement; during shaping and for the first nine days of bar pressing stabilization trials a .1-cc. cup was used; from day nine on a .06-cc. was employed. Bar pressing during the nine minute sessions was recorded by a series of digital counters which registered the number of responses per minute. Cumulative records were obtained with a Gerbrands cumulative recorder.

Procedure

The overall schedule for Study I is shown in Table 2. The schedule was arbitrarily divided into seven

phases. Each phase will be discussed in order.

Table 2

Overall Schedule for Study I

Phase	Activity	Duration
1	Shaping to CRF Bar Pressing: Stabilization	16 days
2	First Conditioning Series	2 days
3	CRF Bar Pressing	1 day
4	Test Days 1 and 2	2 days
5	Second Conditioning	1 day
6	Test Day 3	1 day

All Ss were housed in pairs on arrival at random. They were then given three days of ad lib food and water. At the end of this period all Ss were deprived of water for 48-hrs.

Phase 1

All Ss were shaped to press a lever for water reinforcement. At the end of a three day period of shaping, during which they were allowed approximately 20-min. exposure to water each day, the Ss were placed on a schedule which provided one 9-min. period of bar pressing for each animal per day on a CRF schedule. An additional 15-min. exposure to water in the home cage was also provided 30-min. after each daily bar pressing period. This procedure

remained essentially the same for the subsequent 13 day period. The only alteration in this procedure involved a change in the size of the water cup; the .1-cc water cup used in training and for the early stabilization days was changed in favor of a .06-cc cup on day nine of the 13 day period. When bar pressing behavior had stabilized the Ss were assigned by means of a table of random numbers to treatment groups.

Phase 2

Three treatment groups were employed. For Ss in Groups I and II the conditioning trials were as follows: three minutes of white noise signalled the onset of .5-sec. duration pulses of shock which occurred every 2-sec. (see Figure 1). The number of shock pulses administered on any given trial varied randomly from one to five with an overall average of three shock pulses per trial. When the required number of shocks had been administered E manually terminated the white noise during the 1.5-sec. period between shock pulses. The termination of the white noise marked the onset of the secondary reinforcing stimulus. For Ss in Group III the aversive conditioning procedure was similar to that applied to Groups I and II; however, unlike the procedure given Groups I and II, Group III did not have the pure tone associated with shock or the white noise (see Figure 1). Rather, the tone was presented only during the intertrial interval. Randomized intertrial intervals of 1, 2, 3, 4, and 5 minutes (mean = 3 min.) were employed

for the first series of twenty conditioning trials (given 10 trials per day).

Figure 1

Temporal relationships between shock and conditioned stimuli during conditioning

```
Groups I                             s  s  s
   and II        IIIIINNNNNNNNNNNNNNNNNNNNTTIIIIIIII
                                     s  s  s

                                     s  s  s
Group III        IIIIINNNNNNNNNNNNNNNNNNNNIIIIIITTII
                                     s  s  s
```

Where: N = whitenoise (duration 3-min.+)
s = shock (duration .5-sec.)
T = Tone (duration 1-sec.)
I = inter-trial interval

Phase 3

<u>S</u>s were returned to the bar pressing situation for a single session following the first conditioning series. No conditioned stimuli were presented during this session. This allowed the assessment of the effects of conditioning upon bar pressing behavior.

Phase 4

All groups were tested under the same overall schedule; this involved the division of the 9-min. bar pressing session into three 3-min. periods. During the first 3-min. period the normal CRF bar pressing schedule

was in effect. During the second 3-min. period the conditioned stimuli were superimposed upon the CRF schedule and their effects upon bar pressing were recorded. During the third 3 min. period the normal CRF schedule was in effect. The first period represented normal bar pressing behavior; the second period was the test period; the third period was a recovery period.

The stimuli presented during the second 3-min. period differed according to group assignment. Group I was presented with the white noise during the entire period; in addition, each bar press made by the Ss during this period produced the stimulus previously associated with shock offset. Group II was presented with only the white noise for the entire 3-min. period. Bar pressing delivered only the water reward. Group III was tested under a procedure exactly like that given Group I. The same stimulus durations and intensities were used in training and testing.

Group I was then the major experimental group; their response to the bar press contingent tone presentations assessed the reinforcing or aversive qualities of that stimulus. Group II was a control group used to assess the aversiveness of the white noise alone. Group III was a control for all factors other than the tone's temporal relation to shock.

Phase 5

After the second day of testing six of the eight animals in each group were returned to the conditioning

situation and given ten additional training trials. The procedure during the second conditioning series was the same as it had been for the first conditioning series for groups I, II, and III. The only changes in procedure involved increases in the inter-trial intervals and shock intensity. Intervals of 3, 4, and 5 minutes (mean = 4 min.) were used. The intensity of the shock was increased from 3-m.a. to 5-m.a.

Group IV was created by drawing two animals randomly from each group. These Ss were given 10 conditioning trials under the procedure used to condition Groups I and II.

Phase 7

During this period Groups I, II, and III were tested as before. Group IV was tested with response contingent tone alone superimposed on the CRF schedule during the second 3-min. period. Group IV was then a measure of the aversiveness or reinforcing properties of the tone alone.

CHAPTER III

Results

Study I

The mean response rates per minute for the final day of bar pressing training, the day following the first conditioning series and the individual 3-min. periods on each test day for all groups appear in Table 3.

Table 3

Mean Response Rates for the Final Training Day, the Day after the first Conditioning Series and Test Days 1, 2, and 3

	Final Training Day	Recovery Day	Test Day 1			Test Day 2			Test Day 3		
Period	Full Period	Full Period	1	2	3	1	2	3	1	2	3
Grp. I	11.1	11.9	11.1	1.8	4.6	11.9	4.2	6.9	16.1	4.1	8.0
II	11.7	11.1	12.1	8.3	9.2	12.6	10.2	8.8	11.0	6.7	5.1
III	11.1	11.3	12.7	9.9	11.0	12.8	13.9	11.2	12.4	12.4	10.7
IV	-	-	-	-	-	-	-	-	12.8	9.4	6.5

The mean bar pressing rates for all groups on the final day of bar training, on the recovery day and during the first 3-min. of each test day are uniformly high and very much alike. Indeed, an analysis of variance for randomized groups on the bar pressing rates on the final day of training and on the recovery day, for Groups I - III, revealed no significant

differences ($\underline{F}$ = .23 and $\underline{F}$ = .33 with 2 and 21 d.f.). The group's means also reflect the suppressive effects of the conditioned stimuli presented during the second 3-min. period on each of the test days. The amount of suppression manifested in each group during the second period was evaluated by obtaining different scores between the first and second and first and third 3-min. periods on each of the test days. Statistical analysis of these data was made by means of $\underline{t}$ tests for correlated measures. The results of this analysis can be seen in Table 4.

Table 4.

Summary of $\underline{t}$ Tests for Matched Groups on Differences in Bar Pressing Rates

Differences between periods:	Days 1		2		3	
	1 - 2	1 - 3	1 - 2	1 - 3	1 - 2	1 - 3
Group I	t = 7.31 P <.0005	t = 5.33 P < .005	t = 4.46 P < .005	t = 2.48 P < .025	t = 4.03 P <.0005	t = 2.32 P < .025
Group II	t = 2.46 p < .025	t = 1.61 NS	t = 1.9 NS	t = 2.86 P < .025	t = 2.91 P < .025	t = 3.54 P < .025
Group III	t = 1.89 NS	t = 1.61 NS	t = 1.11 NS	t = 1.14 NS	t = 1.04 NS	t = 1.33 NS
Group IV					t = 3.36 P < .01	t = 2.99 P < .025

The outcome of these comparisons show significant suppression occurred on all the test days in periods 2 and 3 for Group I. Group II showed significant suppression only during period 2

on the first test day, in period 3 on the second day and in both periods on the third day. No significant suppression was found in any period on any of the test days for Group III. Subjects in Group IV showed significant suppression during periods 2 and 3 on the third test day.

To determine whether the differences between groups in the amount of manifest suppression were significant, comparisons were made by means of Duncan's New Multiple Range Test. These comparisons were made using the difference scores obtained in the earlier t test analysis. The results of these analyses appear in Tables 5 and 6.

Table 5

Summary of Duncan's New Multiple Range Tests for Test Days 1, 2, and 3 on Differences Between Bar Pressing Rates in the First and Second Three Minute Periods.

		Group III	Group II	Group I	Shortest Significant Ranges at .05 Level
Day 1					
Means		3.39	3.62	9.33	
Group III	3.39	-	NS	5.94	4.57
Group II	3.62		-	5.71	4.77

Day 2		Group III	Group II	Group I	
Means		1.34	2.86	7.73	
Group III	1.34	-	NS	6.39	4.07
Group II	2.86		-	4.87	4.27

Day 3		Group III	Group IV	Group II	Group I	SSR (.05 level)
Means		.31	3.91	4.24	5.30	
Group III	.31	-	NS	NS	4.99	4.39
Group IV	3.91		-	NS	NS	4.61
Group II	4.24			-	NS	4.75

Table 6

Summary of Duncan's New Multiple Range Tests for Test Days 1, 2, and 3 on Differences between Bar Pressing Rates in the First and Third Three Minute Periods.

	Group III	Group II	Group I		Shortest Significant Ranges at .05 level
Day 1					
Means	1.58	2.95	6.50		
Group III 1.58	-	NS	4.92		4.51
Group II 2.95		-	NS		4.73
Day 2	Group III	Group II	Group I		
Means	1.61	3.94	4.70		
Group III 1.61	-	NS	NS		4.63
Group II 3.94		-	NS		4.86
Day 3	Group III	Group I	Group II	Group IV	
Means	1.40	3.65	5.97	8.03	
Group III 1.40	-	NS	NS	6.63	5.33
Group I 3.65		-	NS	NS	5.61
Group II 5.97			-	NS	5.77

The same trends are revealed in the cumulative records (see Appendix 1) and in Table 4 and 5. Inspection of these data reveals that Group I suffered the greatest amount of suppression; indeed, seven of the eight animals in Group I showed marked suppression to the combined stimuli. Less suppression was produced by presentations of the white noise alone (Group II); the effect was not statistically signific-

ant on the second day of testing. No statistically significant amount of suppression was noted in Group III. In short, maximum suppression was apparent when both the white noise and the stimulus associated with shock offset were presented. Such a finding strongly argues that both stimuli were aversive and summated to produce the greatest amount of suppression. Indeed, the results of the comparisons in Table 5 show no significant differences between Groups II and III on any of the test days. While on test days 1 and 2 Group I showed significantly reduced bar pressing when compared with the other groups. All of these results are consistent with the interpretation of the stimulus associated with shock offset as an aversive stimulus which potentiates rather than mitigates the effects of the stimulus associated with shock onset.

Group IV was created in an attempt to determine whether the stimulus associated with shock offset was an effective suppressor of the bar pressing response when presented alone. That it was can be seen from the data presented in Table 4; when made contingent upon a bar press and presented alone the tone to a significant degree suppressed bar pressing.

Significant suppression generalized into the third three minute period for all but Group III. Data presented in Table 6 shows that the suppressive effects of the stimuli presented during the second three minute period continued to be most disruptive to bar pressing in the third three minute

period for Group I and Group IV. Both of these groups share common conditioning procedures and received response contingent tone presentations during the testing procedures.

The outcome of all of the analyses of the data of Study I are consistent in their result; that is, the greatest amount of suppression appeared in Group I; the greatest amount of generalized suppression appeared in Group I. Significant suppression in Group IV was produced by presentations of the tone alone. All of these results lend no support to the notion that stimuli associated with shock offset gain secondary reinforcing properties. Rather, the results remain a significant finding marking such stimuli as aversive.

Chapter IV

Method

Study II

Study I provided clear behavioral evidence that stimuli associated with shock offset were aversive. Confirmation of such a finding could come through a variety of dependent measures. Indeed, some corroborating behavioral evidence already exists in the work of Forrin (1966). Additional physiological evidence denoting stimuli associated with shock offset as aversive would be powerful supportive evidence. Miller (1951) has speculated as to the functioning of stimuli associated with escape from shock. His hypothesis, adopted by Hall (1952), is termed the "conditioned relaxation hypothesis." Briefly, Miller proposes that such stimuli become conditioned signals for relaxation of muscular tension; such relaxation reduces propreoceptive stimulus intensity (S_D) and thus produces the resulting reinforcement. Mowrer (1959) has proposed somewhat similar formulation in his "hope" hypothesis. Mowrer assumes all primary drives have an anxiety component which is reduced by secondary reinforcement. The combining of these hypotheses with recent data by Sawrey and Sawrey (1964) was the genesis for Study II. Sawrey and Sawrey (1964) have shown that conditioned stimuli previously associated with shock onset, when presented during physical restraint, increased gastric ulceration rates in rats.

Moreover, they found the amount of ulceration to be an increasing function of the number of prior CS-shock pairings. Such findings led the author to believe that gastric ulceration might be an appropriate dependent measure for the assessment of the properties of stimuli associated with shock offset. From the above findings and theoretical formulations it was reasoned that if stimuli associated with shock onset increase gastric ulceration rates then stimuli associated with shock offset might increase resistance to ulceration through some sort of "fear reduction" or "conditioned relaxation" mechanism. Conversely, if stimuli associated with shock offset combined with or produced effects similar to those produced by stimuli associated with shock onset such a finding might be taken as evidence against the theoretical formulations of Miller, Hull and Mowrer.

Additional justification for the choice of gastric ulceration as a dependent measure was found in an earlier study (Zelhart, 1966). In this study rats were trained with distinctive stimuli conditioned to the onset and offset of shock. The Ss were then restrained and various combinations of the conditioned stimuli were presented under extinction procedures. One group was presented with both conditioned stimuli; a second group was presented with the stimulus associated with shock onset; a third group was presented with the stimulus associated with shock offset; a fourth group had been subjected to the prior conditioning

procedures but was not presented with stimuli during restraint. Two control groups were not conditioned prior to restraint. One of these had prior (non-shock) exposures to the conditioned stimuli and received presentations of the conditioned stimuli before or during restraint. The other control group was not exposed to the conditioned stimuli before or during restraint.

In the above study it was hypothesized that if stimuli associated with shock offset are conditioned reducers of drive (Mowrer, 1956, 1959), the Ss in groups receiving such stimuli should be more resistant to gastric ulceration produced by restraint and presentation of conditioned aversive stimuli. The results of the study can be seen in Table 7.

Table 7

Summary of the Results of
Zelhart's 1966 study

Stimuli presented during Restraint: Associated with Shock Onset and Offset		Mean Number of Gastric Lesions
Group I	Both Stimuli	20.3
Group II	Shock Onset Stimulus	13.0
Group III	Shock Offset Stimulus	11.8
Group IV	None	8.8
*Group V	Both Stimuli	1.1
*Group VI	None	4.0

*Groups with no prior conditioning experience.

Statistical comparisons showed Group I to have significantly greater ulceration than Groups IV, V and VI. Additionally,

Groups II and III had significantly greater ulceration when compared with Group V. These results indicate that both stimuli produced similar effects; they summated to produce greater amounts of ulceration. However this study contained some problems. First, the restraining technique did not insure uniform, non-painful restraint. The technique involved wrapping rats in mesh and further restricting their movement by inserting brass rods through the mesh. In such a method skin is necessarily pinched and circulation is often cut off in portions of the body. Secondly, the interval between shock onset and offset was fixed. Such a procedure might reduce the "informational value" of the stimulus associated with shock offset. That is, the Ss could rely upon temporal cues, without attending to the conditioned stimuli, to predict shock offset. The term "information value" is used here in a sense similar to that expressed by Egger and Miller (1962). These authors have shown that the strength of a secondary reinforcer is related not only to its reliability of association with reward but to its uniqueness as a predictor of reward. That is, redundant predictors of reinforcement gain little reinforcing value.

In Study II a similar design and set of procedures was used. However, a less variable and apparently less stressful restraining procedure was developed. Further, variable shock, conditioned stimuli and inter-trial

interval durations were employed in an effort to maximize the signal value of stimuli associated with shock offset.

Two sets of hypotheses were developed concerning the outcome of Study II. (1) If stimuli associated with shock offset become conditioned reinforcers their presentation during restraint might be expected to increase resistance to gastric ulceration produced by restraint and presentations of stimuli associated with shock onset. (2) If stimuli associated with shock offset are similar in effect to stimuli associated with shock onset then the groups presented with such stimuli should show increased rates of restraint produced ulceration; these stimuli should summate in effect when combined.

Subjects

Two hundred male, Sprague-Dawley, albino rats were obtained from the Dan Rolfsmeyers Laboratories of Madison, Wisconsin. Deliveries were in lots of 24 and 40 animals over a 6-mth. period. All Ss were 90 days of age on arrival.

Apparatus

The conditioning apparati consisted of six unpainted wooden boxes. One side of each box was made of glass; the floors were grids composed of 1/8-in. brass rods. The internal dimensions of the boxes were width 12-in., depth 11 1/4-in. and height 12-in. By inserting a partition down the center of each box two separate chambers, both with grid

floors and windows, could be produced. Each chamber was six inches wide, 11 1/4-in. deep and 12-in. high. Thus a total of twelve conditioning chambers were created. A shock of 83-v DC of mechanically "scrambled" shock could be applied to each grid.

Two conditioned stimuli were employed. The stimulus preceding shock was room illumination. This was produced by three 60-watt light bulbs arranged in a row parallel to and 4-ft. above the conditioning chambers. The stimulus used to signal the offset of shock and the aversive stimulus was a tone produced by an outdoor telephone bell (4-in. in diameter). Located approximately 8-ft. from the conditioning chambers the bell made a sound level change in the area of the chambers of approximately 30-db. (from 62-to 92-db.). The duration of the bell was always .5-sec.

Restraint was produced by placing the animals in specially designed and constructed devices pictured in Fig. 3. The restraining devices were fiberglas and were designed to accommodate rats weighing between 210 to 285 grams. A total of 41 such devices were constructed. This was accomplished by making a "female" plaster-of-paris mold of a sacrificed, 230 gram, male rat. "Male" ceramic molds were then fitted to the plaster "female" molds. The resulting "male" molds served as the final mold on to which was fitted each fiberglas half shell. The devices have the advantage of being so molded that they fit every curve of the Ss bodies and provided total support without causing noticeable signs of discomfort. Feet

were taped to the foot rests during restraint with 1/2-in. adhesive tape.

All conditioning and restraint-extinction procedures were carried out in the same location. The room was a garage converted to laboratory space. Temperature regulation in this room was a problem. A relatively constant, high temperature (between 70 and 85 degrees) was maintained through the use of a permanently installed natural gas heater and three 5,000 B.T.U. portable electric heaters. The Ss were maintained in a colony room joining the experimental room when not being restrained or conditioned.

Stimulus and shock presentations were controlled by appropriate timers and relays. All control equipment and shock sources and scramblers were located on the second floor of the house adjoining the experimental room. The animals were thus insulated from the noise resultant from the controlling equipment.

Procedure

In Table 8 an overall schedule for the training and testing schedule of Ss in Study II is presented. The phases noted will be discussed in order in which they appear.

Table 8

Overall Schedule - Study II

Phase	Activity	Duration
1	Laboratory Adaptation Period	3 days
2	Conditioning	1 day
3	Recovery	2 days
4	Restraint	2 days

Phase 1

On arrival all Ss were housed in pairs and given three days ad lib food and water. They were then deprived of food only for 24-hrs. This was done in an effort to make conditioning and restraint cues as alike as possible.

Phase 2

The Ss were placed in the conditioning boxes (one animal per chamber) and the experimental room was darkened. All Ss in groups I - VIII were given the same number of shock and stimuli presentations. A total of 44 stimulus presentations were made of which 22 paired with shock. The order of shock and CS pairing was randomly determined. This partial reinforcement procedure was used to prolong extinction under the restraint procedures.

Groups I - IV were administered the same conditioning procedure. This involved the aversive CS (light) being presented for 6, 8, 10, 12, 14 or 16-sec.; shock (on shocked trials) occurred during the final 3, 4, 5, 6, 7, or 8-sec. of the aversive stimulus. Durations of shock and the aversive stimulus were randomly paired. Light and shock terminated at the same time. Non-shocked trials involved presentations of the conditioned stimuli only. For these groups (I - IV) the bell was sounded for .5-sec. beginning with the onset of the interval when shock was administered; the bell sounded on shock and non-shock trials. Groups V - VIII were given identical training;

these groups received presentations of the aversive conditioned stimulus and shock in the same relationships as those that had been presented to groups I - IV. Only the relationship between shock and the bell was altered. For these groups (V - VIII) the bell sounded .5-sec. before the offset of, and terminated with light and shock.

Two control groups not included in the 2 x 2 x 2 factorial design, were also run prior to the running of the primary experimental groups. Group IX was presented with the conditioned stimuli but was not shocked during the conditioning procedure. Group X was placed in the conditioning boxes for the usual duration of the conditioning procedure but was neither shown the conditioned stimuli nor shocked.

Inter-trial intervals were the same for all groups. Intervals of 2, 3, 4 and 5-min. were randomly assigned to trials. Total conditioning time for the Series of 44 trials was approximately 3-hrs.

Phase 3

After conditioning all Ss were allowed 24-hrs. of ad lib food and water. They were then deprived of food only for the subsequent 24-hr. period.

Phase 4

When the Ss were 24-hr. food deprived they were placed in the restraining devices in the experimental

room. Ss were deprived 24 hours before restraining to eliminate food from their stomachs. The deprivation period eliminated food from their stomachs, facilitated ulceration, and provided assurance that the Ss were uniform with regard to the amount of "buffer substances" existant in the stomach at the time of restraint. During restraint the conditioned stimuli were presented for the same durations and at the same intervals employed during conditioning.

The design of the study thus was a 2 x 2 x 2 factorial design (Groups I - VIII). The factors were (A) the placement of tone at the onset or offset of shock during training, (B) the presentation or non-presentation of light during restraint, (C) the presentation or non-presentation of tone during restraint. Two control groups, not included in the design, were also run. The design of the study and the stimuli presented to the various groups can be seen in Table 9.

Table 9

Groups for which the tone accompanied shock onset during conditioning.

Group:	Stimuli presented during restraint	
	Light	Tone
I	YES	YES
II	YES	NO
III	NO	YES
IV	NO	NO

Groups for which the tone accompanied shock offset during conditioning.

Group:	Stimuli presented during restraint: Light	Tone
V	YES	YES
VI	YES	NO
VII	NO	YES
VIII	NO	NO

Control groups: IX having prior experiences with the stimuli X having no prior experience with stimuli

Group:	Stimuli presented during restraint: Light	Tone
IX	YES	YES
X	NO	NO

During restraint Group I received presentations of light and tone which were like the stimulus presentations during conditioning. That is, light came on; at the time when shock would have appeared the tone sounded the light then continued for an additional 3- to 8-sec. For Group V, the light was presented for from 6 to 16-sec.; the tone accompanied the final .5-sec. of the light. Groups II and VI received only light presentations. Groups III and VII received only tone presentations. Groups IV and VIII received no stimulus presentations during restraint. The procedure allowed groups to be run in pairs; that is,

members of Groups II and VI, Groups III and VII, and Groups IV and VIII were run concurrently. Group I and Group V, due to the stimuli presented to them, had to be run individually. Groups IX and X were also run individually. Eight to 12 animals for a group were run at a time as Ss arrived in the laboratory. Each lot of animals was randomly assigned to groups.

At the end of the 48-hr. period of restraint all Ss were sacrificed; their stomachs were removed and examined. The number and size of the lesions found were recorded. The greatest distance across a lesion was taken as its size; lesions of less than 1-mm were denoted in a single class as "pin point" lesions. For the sake of later data analyses these lesions were given a constant value of .5-mm.

Chapter V

Results

Study II

The mean number and size gastric lesion found in each group is listed in Table 10.

Table 10
Average Number and Size Gastric Lesion

Groups	I	II	III	IV	V	VI	VII	VIII	IX*	X*
Number	3.20	2.05	1.25	3.50	4.55	2.40	1.70	1.20	.05	.50
Size (mm)	1.36	1.23	.74	.56	.77	.03	.83	.63	.13	.18

*Groups not included in the 2 x 2 x 2 factorial design.

From the means presented in Table 10 it can be seen that in general greater amounts of gastric ulceration resulted in groups that were presented with stimuli combinations during restraint that were more similar to those presented during training. Thus Groups I and V showed larger lesions and higher rates of ulceration when compared with their control groups. The only exception to this trend can be seen in Group IV; however, the apparently high rate of ulceration in this group is a product of one severely ulcerated animal. The exception (Group IV) does not manifest itself when the average size of lesion is evaluated. Basically the data are similar to those found by Zelhart (1966).

Determination of the significance of the effects of the various treatments, which resulted in the means noted above, was made by 2 x 2 x 2 factorial analysis of variance procedures. These procedures were used to evaluate differences in both size and number of gastric lesions found in Groups I - VIII. A summary of these data can be found in Tables 11 and 12.

Table 11

Summary of 2 x 2 x 2 Factorial Analysis of Variance on Number of Lesions

Source of Variation	Sum of Squares	d.f.	Means Square	F
A: Training	0.0	1	0.0	-
B: Light	55.22	1	55.22	1.71*
C: Tone	7.22	1	7.22	-
A x B: Training x Light	28.90	1	28.90	-
A x C: Training x Tone	32.40	1	32.40	-
B x C: Light x Tone	60.03	1	60.03	1.86*
A x B x C: Training x Light x Tone	6.40	1	6.40	-
Error: Within Treatments	4,905.60	152	32.27	

*Needed at .05 Level of Significance is 3.91

Table 12

Summary of 2 x 2 x 2 Factorial Analysis of Variance on Size of Lesion

Source of Variation	Sum of Square	d.f.	Mean Square	F
A: Training	.92	1	.92	-
B: Light	6.70	1	6.70	4.44*
C: Tone	.46	1	.46	-
A x B: Training x Light	2.33	1	2.33	1.54*
A x C: Training x Tone	.31	1	.31	-
B x C: Light x Tone	.60	1	.60	-
A x B x C: Training x Light x Tone	.15	1	.15	-
Error: Within Treatments	228.65	152	1.51	

*Needed at .05 Level of Significance is 3.91.

From the data analyses presented in Tables 11 and 12 apparent that only one component was significant. The B component in the analysis using size of lesion as the basic data showed that Ss presented with the conditioned stimulus that preceded shock had significantly larger lesions than did Ss not presented with such stimuli.

In order to determine if there were any significant differences between all groups in either number or size of gastric lesions additional comparisons were made by means of Duncan's New Multiple Range Test. These comparisons revealed that Group I, which was presented with both stimuli during restraint, had significantly larger lesions than did control

Groups IX and X. Group V, which was presented with both stimuli during restraint, had on the average significantly more lesions than did Groups VIII, IX and X. Groups I and IV had significantly more lesions than did Group IX. The .05 level of significance was used for all range tests.

The results of Study II present an interesting, if frustrating, set of phenomena. Most certainly the restraining technique employed in the present study produced a result unlike the results obtained by Sawrey and Sawrey (1964) and Zelhart (1966). While the restraining technique employed in the present study effectively immobilized the _S_s a comparatively small amount of gastric ulceration resulted. This finding combined with extensive use of both techniques leads the author to conclude that the major factor in restraint-produced ulceration, in previous studies, was discomfort rather than immobilization. The restraining technique used by Sawrey and Sawrey (1964) and Zelhart (1966) involved wrapping rats in wire mesh through which brass rods were inserted to further restrict the animals' movements. This method, unlike the method used in Study II, always produced a number of fatalities by the end of the restraining period. The author did all of the restraining of animals in both of the studies mentioned above with full knowledge of the _S_s groups assignment. If discomfort as a major factor in restraint produced gastric ulceration,

the results of both of the previous studies may reflect the experimenter's vigor in restraining rather than the effect of the conditioned stimuli. From the results of the present study no conclusive statement can be made on this point. However, the single significant component of the analyses of variance lends partial support to the veracity of previous research. That is, the analyses of variance using size of the lesion as the basic datum revealed that Ss presented with the aversive stimulus during the restraint period had significantly larger lesions than did Ss not presented with such stimuli. The analyses using Duncan's Range Test supports this result. These analyses showed Groups I, IV and V had more, and in the case of Group I larger, lesions than did the groups not receiving prior conditioning. It is also informative to note that Group V, a group presented with both stimuli during restraint, had significantly more lesions than did Group VIII which was previously conditioned but was not presented with the conditioned stimuli during restraint.

Thus, there is very modest evidence supporting previous research. However, it would seem that as employed in Study II gastric ulceration was not sensitive enough to provide evidence on the status of stimuli associated with noxious stimulation.

CHAPTER IV

Discussion

In discussion of these studies it would seem appropriate to deal with them in reverse order. Study II provided no evidence bearing upon the major concern of the present research. The major procedural failure, as noted earlier, in Study II involved the use of a restraint technique that produced a very low rate of gastric ulceration. Gastric ulceration may be an appropriate measure for assessing differences between stimuli associated with shock onset or offset. However, before it is used additional research dealing with the effects of various restraint techniques is needed. Some support of previous research (Sawrey and Sawrey, 1964 and Zelhart, 1966) was found in the significant "B" component of the analysis of variance which used lesion size as data. This result indicates that resistance to ulceration is reduced by the presentation of stimuli which had previously been associated with shock and it points up the potential of gastric ulceration as a dependent measure.

Study I, conversely, provides very clear evidence concerning the reinforcing or aversive effects of stimuli associated with the offset of shock. Such stimuli in Study I were shown to be aversive. The highly significant

suppression apparent in Groups I and IV is strong evidence favoring such an interpretation. It only remains that these findings be integrated into the theoretical and empirical literature dealing with secondary reinforcement.

In relation to the studies reviewed earlier the present study has no real counterpart. In result and design it is most similar to Forrin's (1966) study. However, Forrin, by his own statement, failed to provide certain necessary control groups (see Forrin, 1966). The present study maximized the possibility of conditioning secondary reinforcers to shock offset and included in the design methods for assessing any aversive properties such stimuli might acquire. The results are clear and are open to only one interpretation; stimuli which signal the termination of shock are, for rats, conditioned aversive stimuli. The author does not wish to endorse the fallacy of the crucial experiment and realizes that no one experiment or series of experiments will invalidate the theoretical position that prompted the present study. Most certainly the present study should be reinforced through a variety of approaches including replications which might employ subjects more highly developed than the albino rat. It may well be that a phenomenon which is as intuitively appealing as Mowrer's "hope" concept could be demonstrated in organisms capable of verbal mediation. However, none of the theorists that employ a concept of secondary reinforcement claim that it manifests itself only in man. The pres-

ent investigation and like findings require additional specification of the conditions necessary and sufficient for the production of secondary reinforcement through association with aversive stimulus offset by the employers of such concepts. Conversely, if additional specification is not more successful in result, the theories that proposed such concepts should be modified.

Three contemporary learning theorists, Brown, Mowrer and Miller (prior to 1963), employ concepts of secondary reinforcement that would seem to depend on a positive demonstration that secondary reinforcing properties can be conditioned by pairing neutral stimuli with noxious stimulus offset. These theorists, to greater or lesser degrees, embrace theoretical formulations that have their origins in the works of Clark Hull.

Hull took, as Miller (1963) terms it, a "strong form of the drive-reduction hypothesis." Briefly, Hull's (1952) final formulation of his theory stated that behavior was the result of primary need or deprivation which he defined in terms of physiological need states, avoidance of pain,

etc. Such need states eventuate in drive (D) which Hull conceived to be a non-specific state of the nervous system; "D represents, then, the total effective drive strength operating in the organism at the given moment" (1952, 249); drives instigate behavior. The direction that behavior takes is learned. Learning occurs, under Hull's system, when needs and their accompanying distinctive internal stimuli (S_D) are rapidly reduced in intensity. Restated, learning occurs when there is a rapid dimunition in S_D usually accomplished through need reduction. Further, need prompted behavior has direction because each need has distinctive propreoceptive stimuli (S_D). Objects capable of reducing primary need states were termed "primary reward" or reinforcement. Hull recognized that primary needs and reinforcement could not account for all behavior. So, two additional concepts were proposed. Both concepts state that neutral stimuli when paired with primary drive and reinforcement gain properties similar to D and reinforcement. "When neutral stimuli are repeatedly and consistantly associated with the evocation of primary drive ... and this drive stimulus undergoes abrupt dimunition, the hitherto neutral stimuli acquire the capacity to bring about the drive stimuli (S_D) which thereby become the condition (C_D) of a secondary drive or motivation". (Hull, 1952). This then is Hull's concept of acquired drive. His concept of secondary rein-

forcement is similarly stated. "A neutral receptor impulse which occurs repeatedly and consistently in close conjunction with a reinforcing state of affairs ... will itself acquire the power of acting as a reinforcing agent" (Hull, 1951). Leaving aside the many criticisms that have been leveled at the lack of precision in these statements, it can be seen that the critical event for the learning of secondary drives and reinforcement is a rapid dimunition in drive stimuli. No distinctions between classes of drives or reinforcers was made. It was assumed that relief from noxious stimulation was similar in effect to relief from hunger or thirst. Subsequent research has not found things to be so tidy. Miller, for instance, has been unable to condition the S_D's of hunger and thirst to neutral stimuli after several years of continued research in the area. Additionally the concern of the present research, the conditioning of secondary reinforcers through association with shock offset, has not been satisfactorily demonstrated.

However, several authors have continued to use Hull's formulation. Miller's "anticipatory relaxation hypothesis", adopted by Hull, is a good example. Miller proposes that escape from shock not only reduces pain but cues associated with shock reduction become condition cues for the relaxation of fear (autonomic activity). Brown (1960) has extended this argument to state that most human behavior can be accounted for in terms of a fear reduction model. He

accounts for money seeking behavior, for instance, by saying that through a classical conditioning paradigm the absence of money and its associated symbols become a conditioned stimulus for fear. Money acquisition reduces the conditioned aversive stimuli associated with poverty and hence fear is reduced. Through continued pairings money becomes a conditioned secondary reinforcer. He extends this analogy to many other forms of behavior. Indicating, basically, that stimuli that precede the offset of pain and accompanying fear become conditioned reinforcers capable of reducing fear.

Mowrer (1956 and 1959) has made a similar kind of argument but has to some extent rejected the Hullian formulation of learning. Mowrer's "final" revision of two-factor learning theory attempted to unite the data from studies of avoidance, punishment and secondary reinforcement. This revision broke with previous two-factor formulations in that it postulated conditioned emotional states as mediators for both conditioning (sign learning or stimulus substitution learning) and habit formation (trial and error learning or solution learning). Mowrer acknowledges that a number of distinct and conditionable emotional states may exist; he, however, discusses extensively only two--"fear" and "hope". Operationally he defines fear as the emotion conditioned to stimuli that immediately precede noxious stimulus onset. Hope was defined as the emotion conditioned to stimuli that

precede the offset of noxious stimulation. The fear construct was of course derived from studies of punishment and avoidance; the hope construct was derived from the phenomena of secondary reinforcement. For Mowrer, the direction behavior takes is determined by classically conditioned emotional responses that "direct" the organism to minimize fear. Certainly ample evidence exists for a concept like fear; however, critical to Mowrer's theory is the demonstration that stimuli preceding noxious stimulus offset gain secondary reinforcing properties. From the literature review presented earlier it is evident that the necessary demonstration has not been generally made.

It would seem then that Hull, Miller, Brown and Mowrer are theorizing not only without adequate supportive data, but from the results of Study I, they may be hypothesizing a phenomena that cannot be demonstrated. The present experiment is of course bound in its generality to the specie employed as subject and to the procedures employed. Another species and set procedures, as Dinsmoor's studies may indicate, might produce the phenomena. However, the onus for such a demonstration would seem to rest with those who predict the phenomena. Failure in such a demonstration should produce a demand for the re-evaluation of the drive-reduction model of secondary reinforcement.

Alternative models are available and have been

entertained by Miller (1963), Spence and Lippitt (1940), Spence, Bergmann and Lippitt (1950), Spence (1947, 1951a, b, 1956, 1960), Seward (1950, 1951, 1952, 1953, 1956) and Sheffield, Roby and Campbell (1954). Rather than emphasizing the drive reducing qualities of incentives these authors emphasize the drive inducing qualities of incentives.

Wike (1966) in his review of the literature dealing with secondary reinforcement in general states, "while there is some evidence that secondary reinforcing stimuli do have on energizing effect the evidence is not unequivocal, and we expressed a reservation regarding the feasibility of an energizing interpretation of all the diverse secondary reinforcement phenomena." Despite Wike's reservation Study I and the other negative findings reviewed earlier may demand alternative formulations of secondary reinforcement. While there has been no shortage of speculation, all of these formulations do suffer from logical and empirical difficulties. It is likely, then, that a sounder empirical base may be necessary before a definitive theory is able to be formulated.

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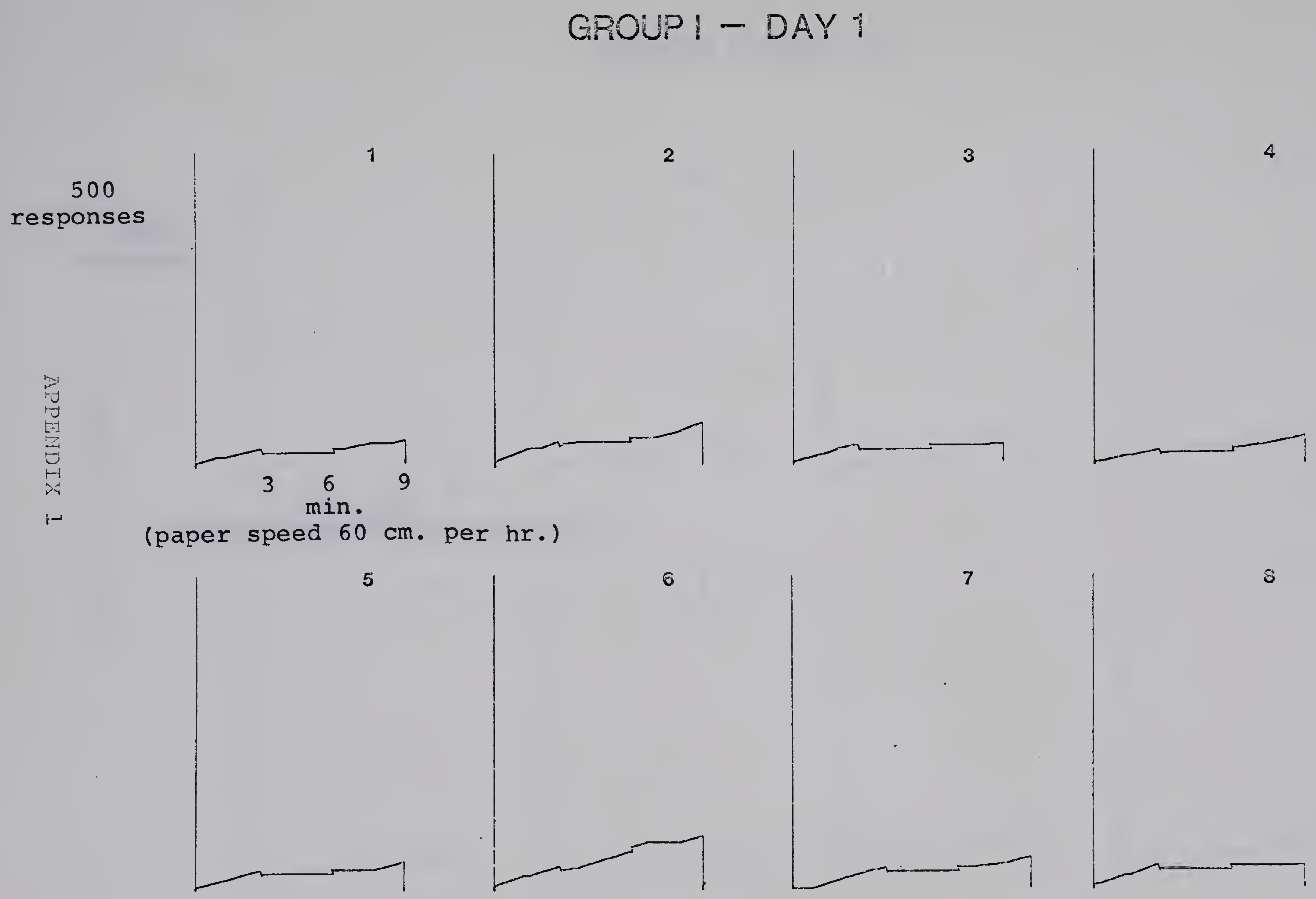
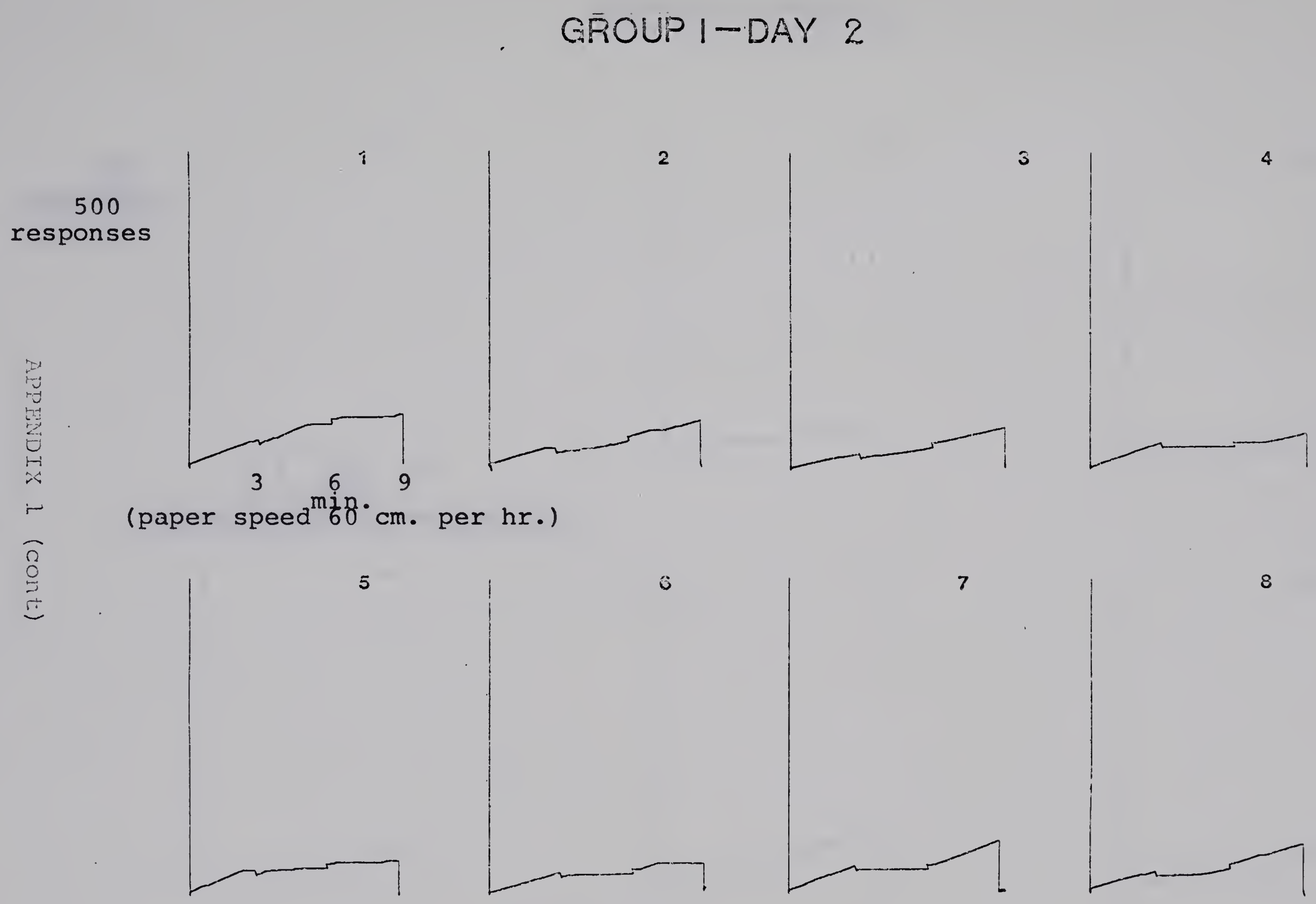
APPENDIX 1



Cumulative Records

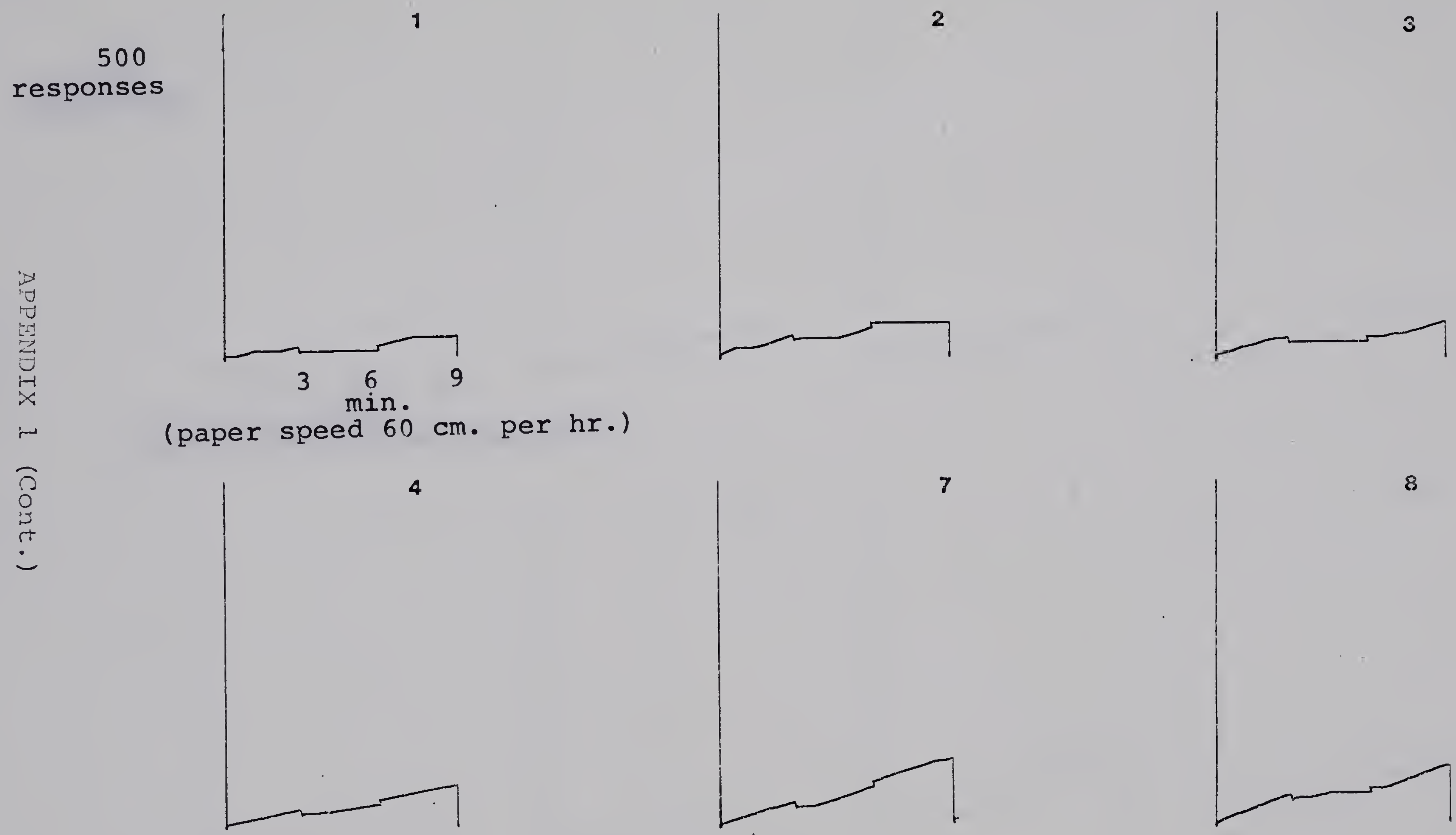
APPENDIX 1 (cont)



Cumulative Records

APPENDIX 1 (Cont.)

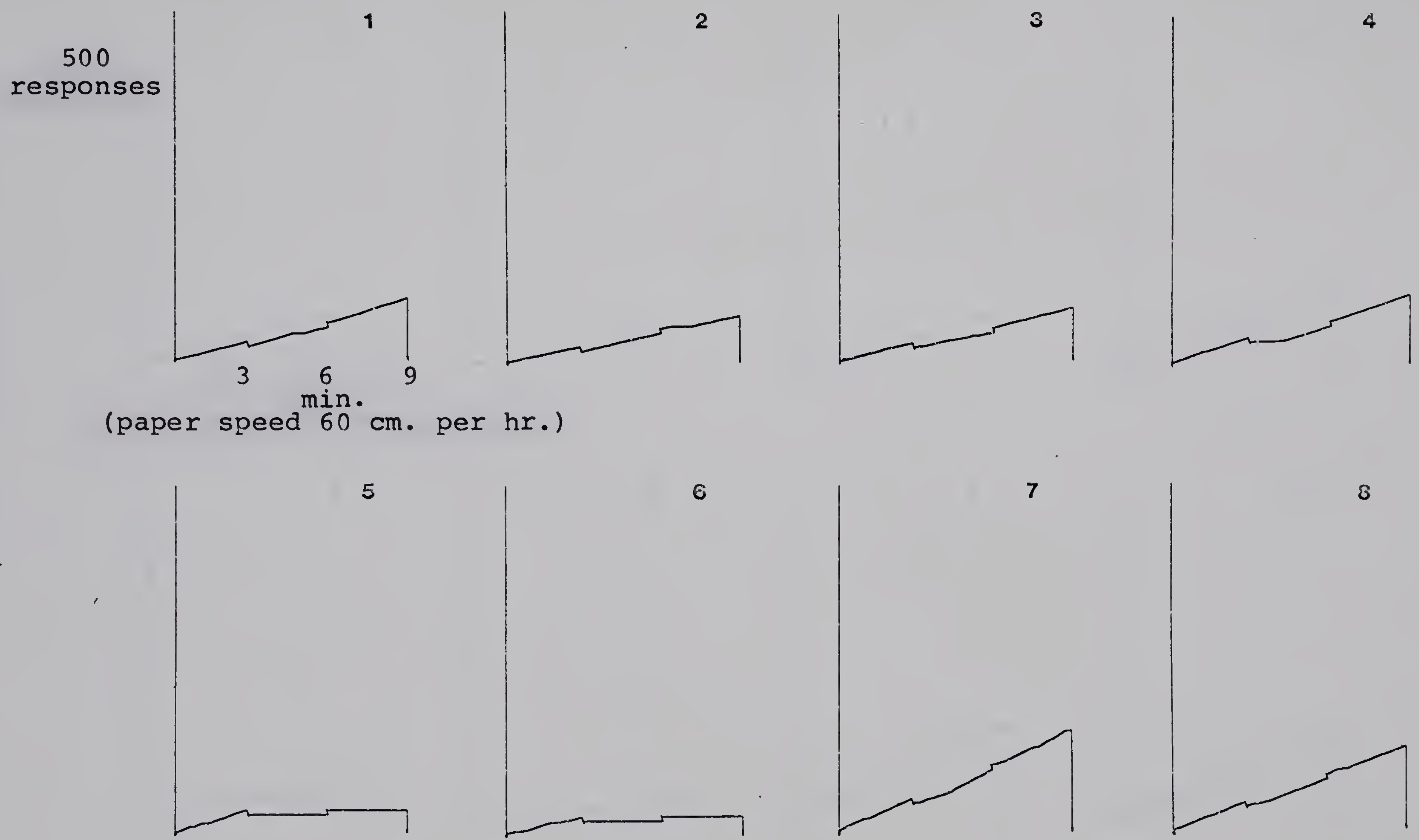
GROUP I — DAY 3



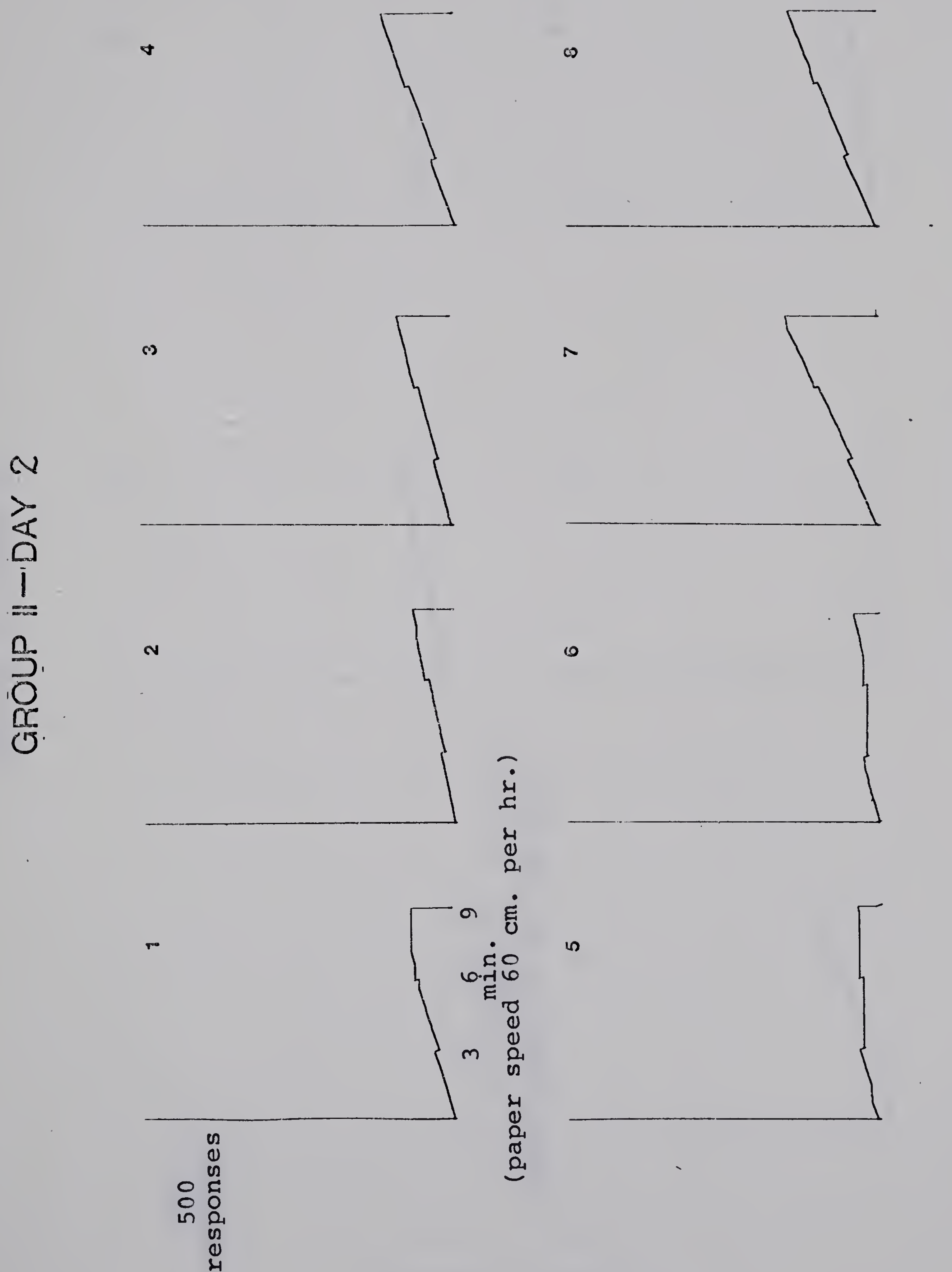
Cumulative Records

APPENDIX 1 (cont.)

GROUP II — DAY 1



Cumulative Records

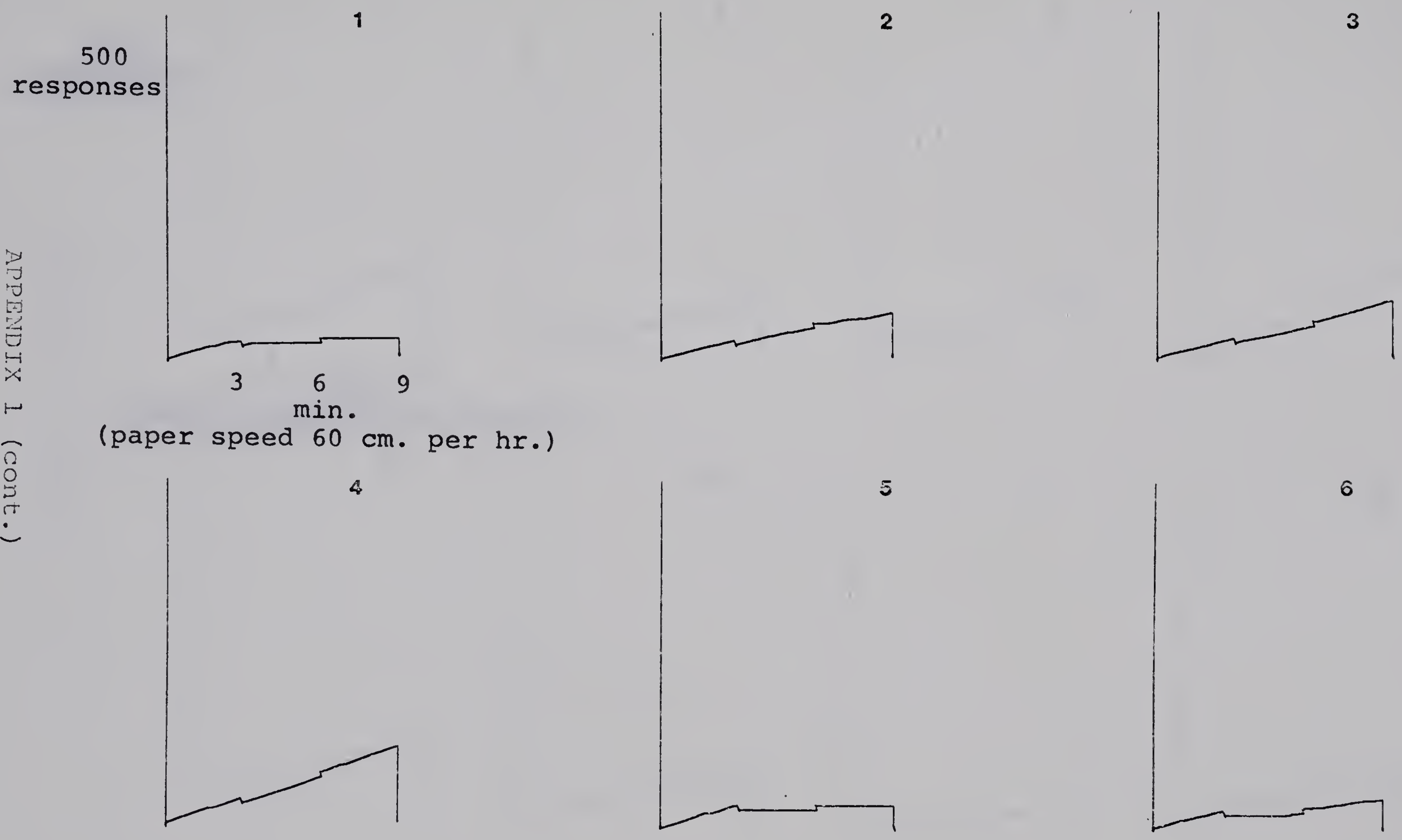


Cumulative Records

APPENDIX 1 (cont.)

APPENDIX 1 (cont.)

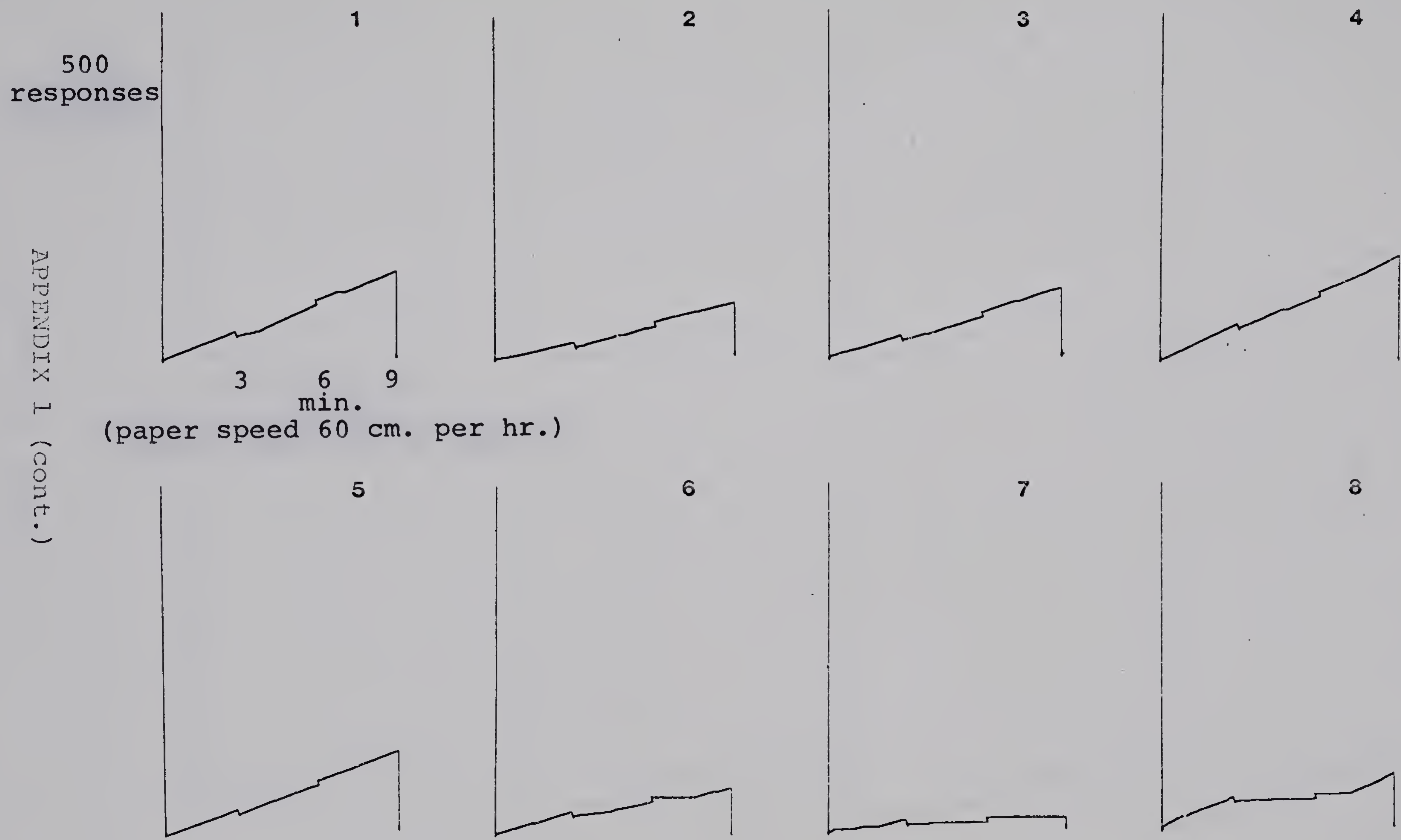
GROUP II — DAY 3



Cumulative Records

APPENDIX 1 (cont.)

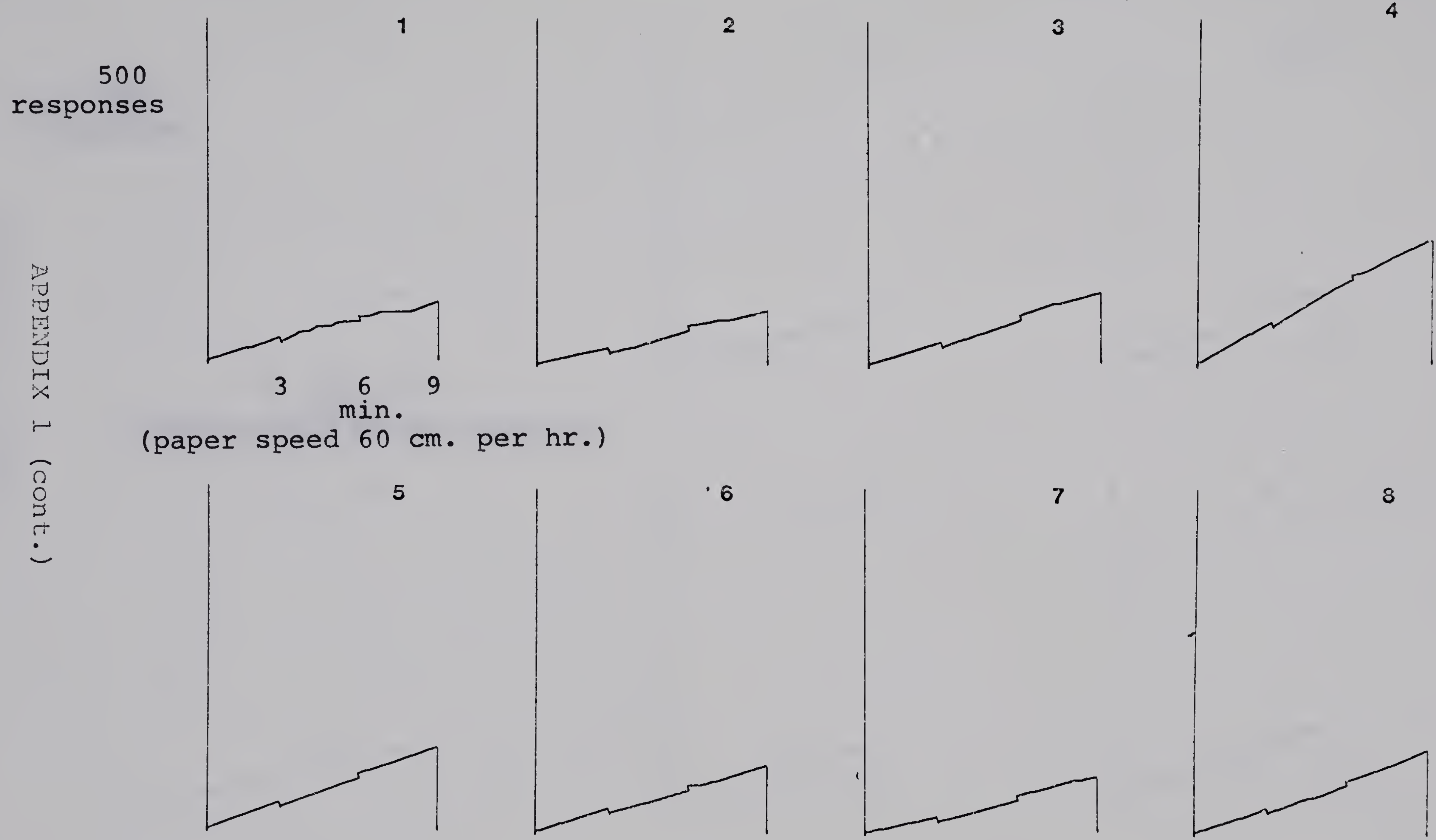
GROUP III—DAY 1



Cumulative Records

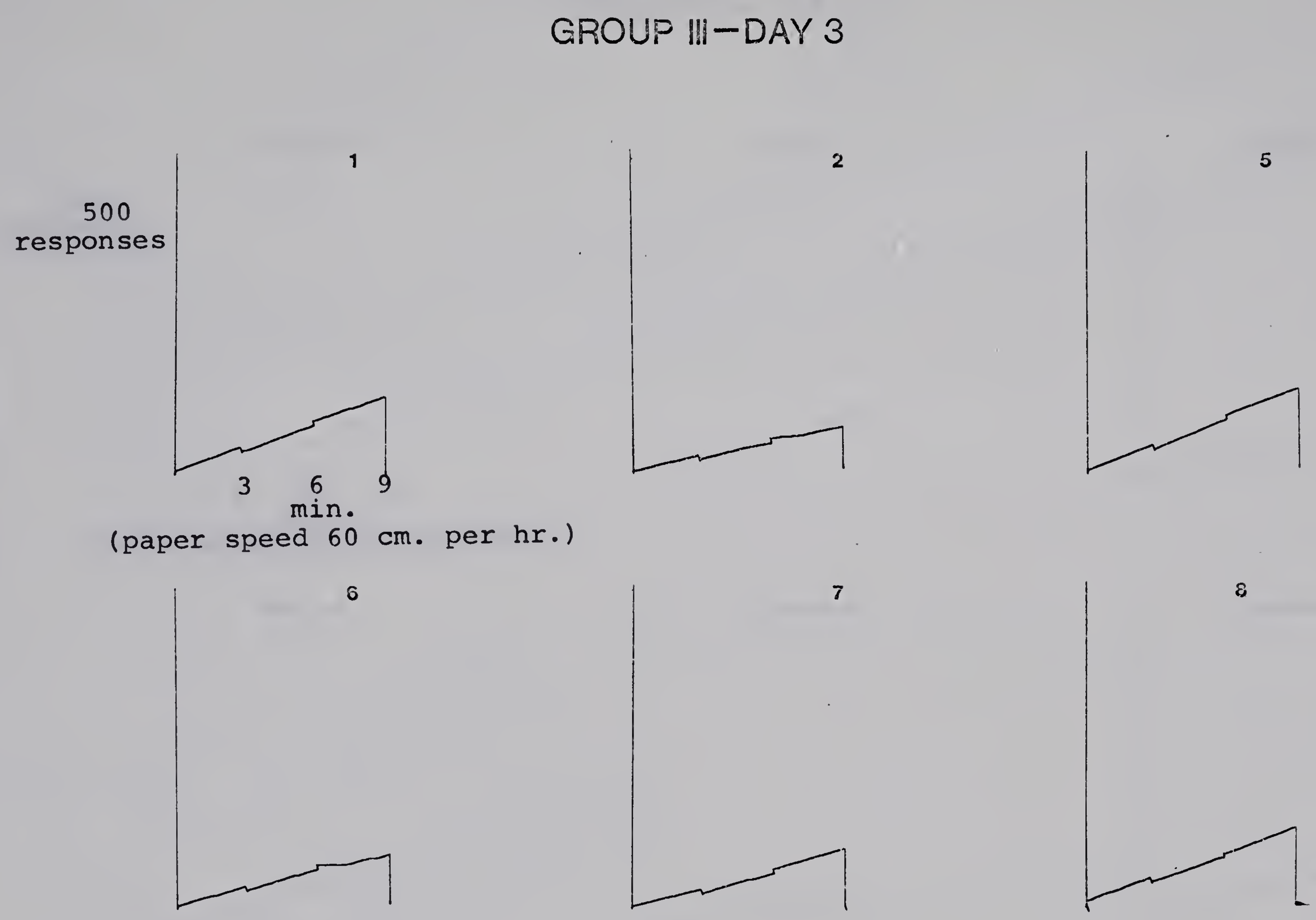
APPENDIX 1 (cont.)

GROUP III — DAY 2



Cumulative Records

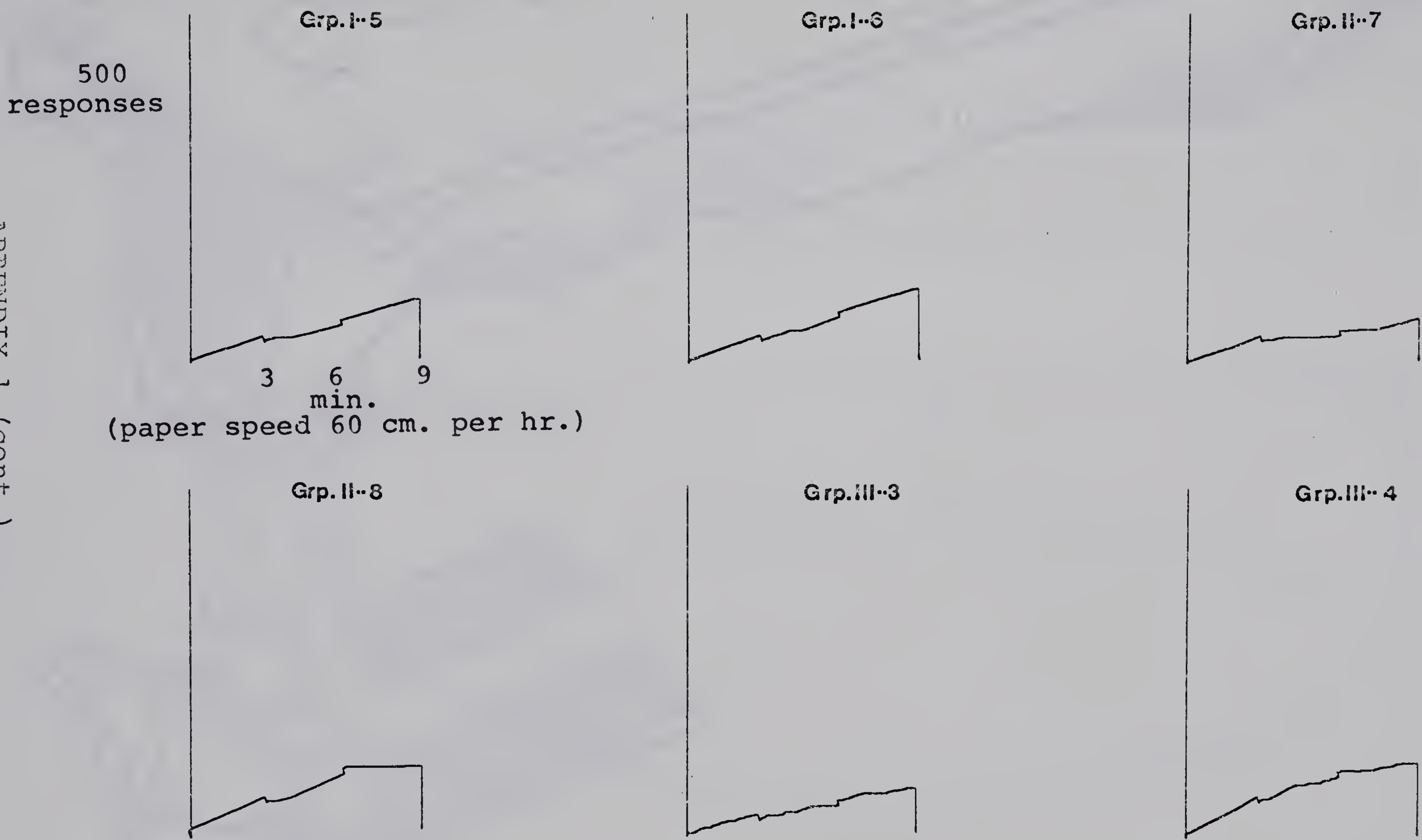
APPENDIX 1 (cont.)



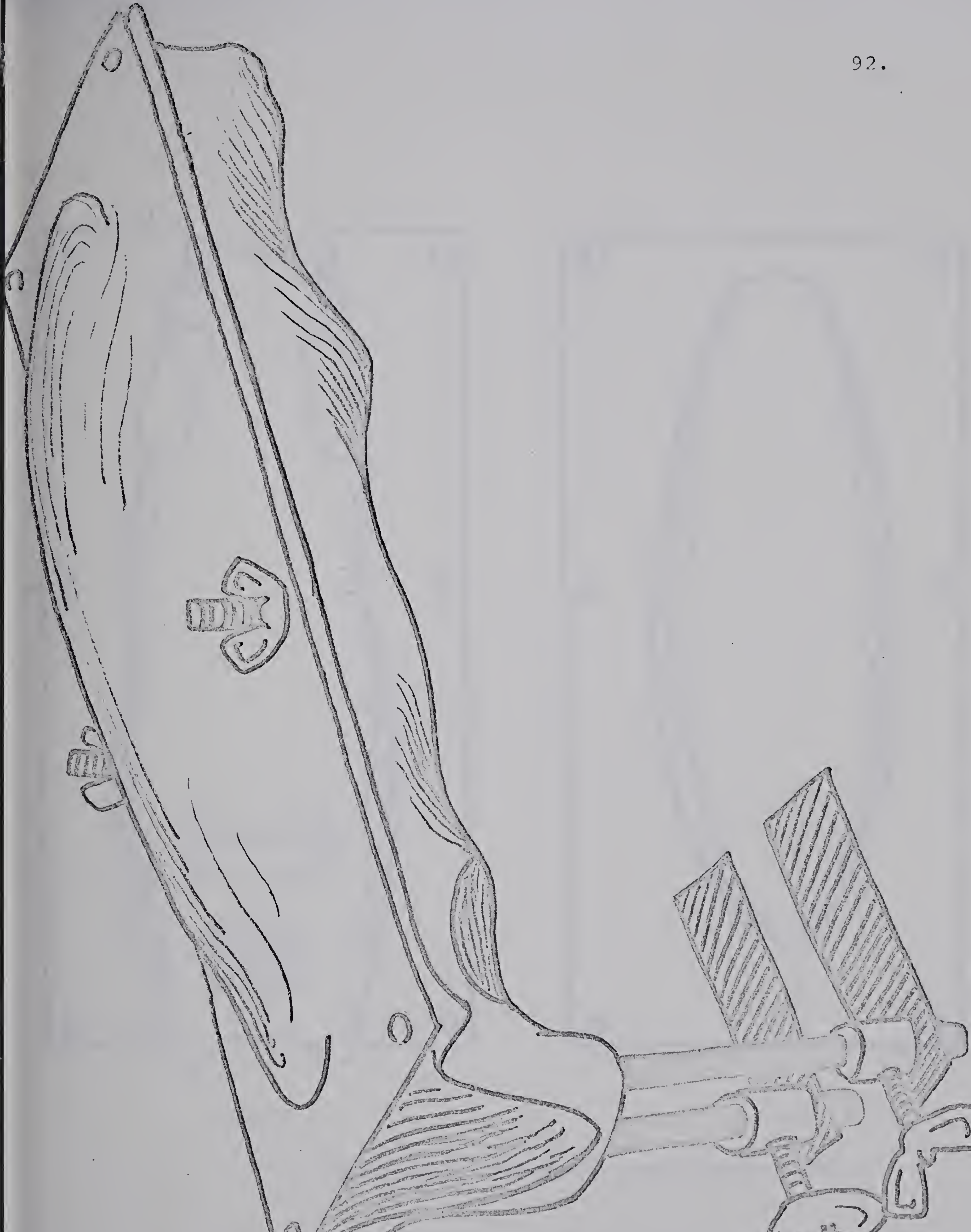
Cumulative Records

APPENDIX 1 (cont.)

GROUP IV— DAY 3

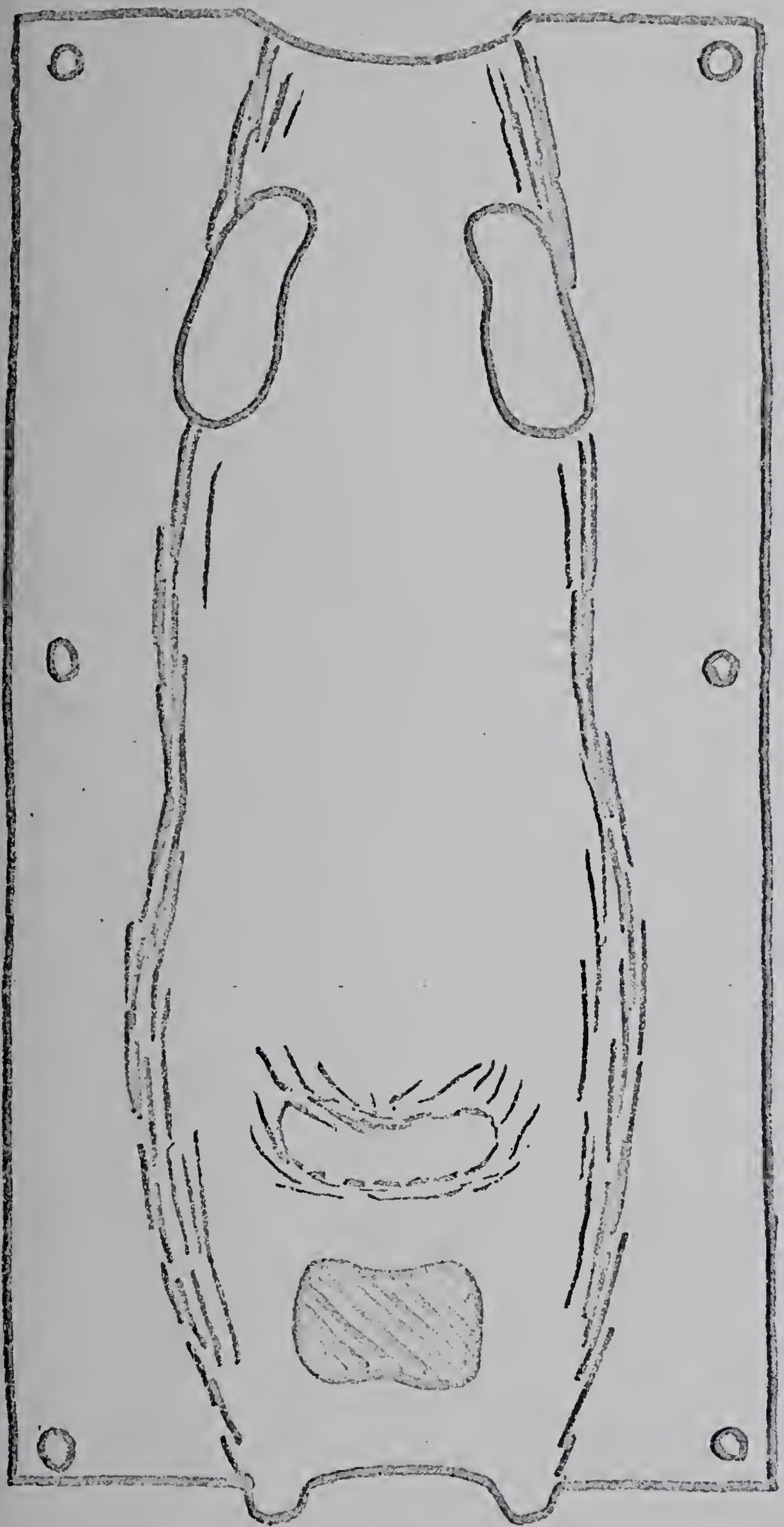


Cumulative Records

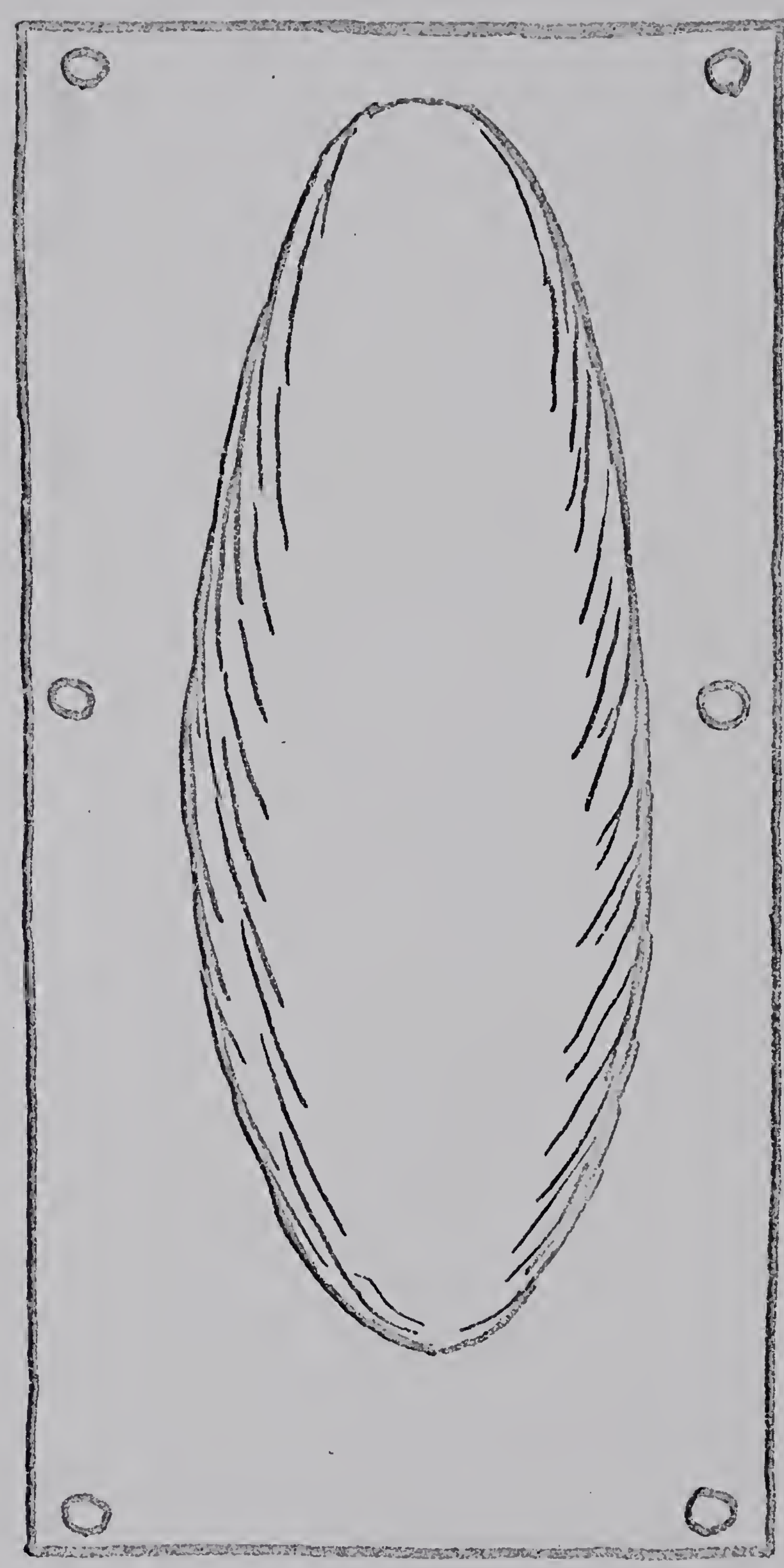


Drawing of Fiberglas restraining device

APPENDIX 2



bottom



top

Drawings of Fiberglas restraining device

end profile

APPENDIX 2 (cont.)